APPENDIX E

Water Supply Technical Report

San Francisco Bay Area Environmental Management Plan

June 1978

This plan was prepared by the Association of Bay Area Governments with a grant and other assistance from the Environmental Protection Agency, in cooperation with Bay Area Air Pollution Control District, Metropolitan Transportation Commission, San Francisco Bay Regional Water Quality Control Board and Counties of the Bay Area with assistance of these agencies: ■ Army Corps of Engineers ■ California Air Resources Board ■ California Department of Health ■ California Department of Transportation ■ Council of Bay Area Resource Conservation Districts ■ Governor's Office of Planning and Research ■ Lawrence Berkeley Laboratory ■ Lawrence Livermore Laboratory ■ San Francisco Bay Conservation and Development Commission ■ State Water Resources Control Board ■ State Solid Waste Management Board ■ Wastewater Solids Study

ABAG

APPENDIX E

WATER SUPPLY TECHNICAL REPORT

This report was prepared for the Association of Bay Area Governments by J. B. Gilbert and Associates. The material in the report was the basis for the recommendations in the Water Supply Chapter of the Environmental Management Plan, June 1978.

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EXECUTIVE SUMMARY

INTRODUCTION

A regional water conservation, reuse, and supply study was prepared for the Association of Bay Area Governments (ABAG). It is one of seven elements of the Environmental Management Plan which the U. S. EPA directed ABAG to prepare for the San Francisco Bay Area under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. The other six elements of the Plan relate to surface runoff, air quality maintenance, municipal wastewater facilities, industrial discharges, nonpoint sources other than surface runoff, and solid waste.

The study was conducted during a severe drought, the worst in modern times. The drought forced mandatory cutbacks in water use throughout the Bay Area and has caused water planners to revise downward their estimates of how much water existing systems can reliably deliver. It has raised questions concerning the future standards for water supply planning, the need for shared use of existing supplies, the long-term desirability of various short-term water conservation measures, and the level to which the quantities of wastewaters should be reclaimed and used to supplement basic water supplies. This study provides an integrated analysis of these alternative approaches to water management that can be applied to local and other regional areas to obtain a more efficient water management program. It is a limited analysis in that the experience of water management during a drought has been relatively short and long-term strategies have not been tested. The approach, however, is an attempt to inspect a complex urban area's total water supply while recognizing the institutional, legal, and physical constraints that limit an area's ability to make the most efficient use of its waters. This analysis will aid in identifying those areas where changes in operations might be to everyone's benefit.

WATER SUPPLY

During 1975, the San Francisco Bay Area used about 1,580 million gallons per day (mgd). The largest category of use was agriculture, which used 645 mgd or 41 percent of the total. Residential

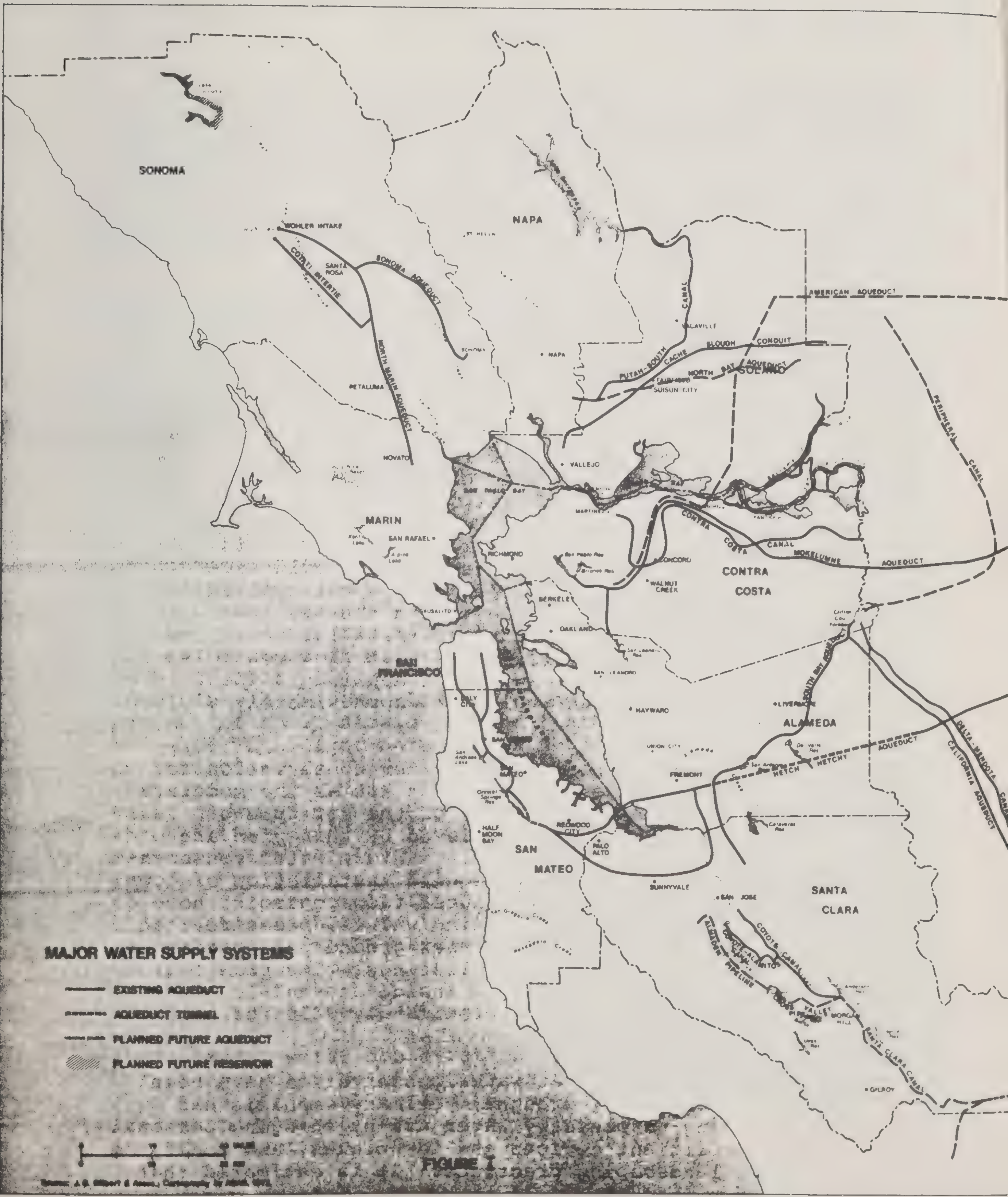
use accounted for 502 mgd, or 32 percent. Approximately 69 percent of the residential water was used inside the home for toilet flushing, bathing, laundry and cooking. The other 31 percent of the residential water was used outside the home for lawn and garden watering, car washing, and other uses. Commercial and industrial users consumed 312 mgd, or 20 percent of the total water used in the region. Public authorities (government buildings, parks, etc.) used 61 mgd; a similar amount of water was unaccounted for, i.e., withdrawn from fire hydrants or lost through system leaks.

Half of the water used in the Bay Area is imported via aqueducts from reservoirs in the Sierra Mountains. Location of the major aqueducts in the Bay Area are shown on Figure 1. The City and County of San Francisco imports approximately 270 mgd from the Hetch Hetchy project. the East Bay Municipal Utility District imports approximately 190 mgd from the Mokelumne River, and the State Water Project's South Bay Aqueduct provides approximately 120 mgd. A substantial amount of water (210 mgd) is diverted by local agricultural and industrial users directly from the Sacramento-San Joaquin Delta. The largest source of water generated within the Bay Area is Lake Berryessa, which supplies 200 mgd. The Russian River supplies over 50 mgd and a number of other small reservoirs provide 110 mgd. Approximately one-fourth of the water comes from groundwater. Groundwater supplies about half the needs of Santa Clara and Sonoma counties and about one-third the needs of Alameda and Solano counties.

Seven major aqueduct systems are operated by separate, independent special districts except for the Hetch Hetchy system, which is operated by the City and County of San Francisco. About 70 more agencies, cities, or special districts are involved in distributing water to homes, industries, and farms. In the future, up to 2,512 mgd of water supply could be made available; 543 mgd could be supplied from new sources outside the immediate Bay Area. These projects would require construction of the proposed aqueducts shown on Figure 1.

EFFECTS OF WATER CONSERVATION ON WATER USE

Water used by residential customers inside the home presently accounts for 37 percent of total municipal water use, and outside residential water use represents 17 percent. Inside residential water use is expected to increase 30 percent in the next 25 years.



SONOMA
NAPA
SOLANO
MARIN
CONTRA COSTA
ALAMEDA
SAN FRANCISCO
SAN MATEO
SANTA CLARA
WOHLER INTAKE
COTATI INTERTIE
SANTA ROSA
SONOMA AQUEDUCT
NORTH MARIN AQUEDUCT
SONOMA
NAPA
PETALUMA
NOVATO
SAN RAFAEL
SAUSALITO
SAN PABLO BAY
VALLEJO
MARTINEZ
RICHMOND
BERKELEY
OAKLAND
SAN LEANDRO
CONCORD
WALNUT CREEK
HAYWARD
UNION CITY
FREMONT
LIVERMORE
DALY CITY
SAN MATEO
HALF MOON BAY
REDWOOD CITY
PALO ALTO
SUNNYVALE
SAN JOSE
MORGAN HILL
GILROY
VACAVILLE
SUISUN CITY
CANAL
PUTAH-SOUTH
CACHE SLOUGH CONDUIT
NORTH BAY AQUEDUCT
AMERICAN AQUEDUCT
PERIPHERAL CANAL
CONTRA COSTA CANAL
MOKELUMNE AQUEDUCT
SOUTH BAY AQUEDUCT
HETCH HETCHY AQUEDUCT
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
COYOTE CANAL
ALMADEN PIPELINE
SANTA CLARA CANAL
MAJOR WATER SUPPLY SYSTEMS
EXISTING AQUEDUCT
AQUEDUCT TUNNEL
PLANNED FUTURE AQUEDUCT
PLANNED FUTURE RESERVOIR

FIGURE 1

Outside residential water use is expected to increase 127 percent. This shift in pattern of residential use will be due to the expected decline in household size, causing an increase in dwelling units of approximately twice the rate of population growth. Moreover, the majority of new housing is expected to be of the low-density type, which traditionally has had high outside water usage. Commercial and industrial water use is projected to increase 33 percent in the next 25 years.

Currently available water conservation measures and devices were evaluated to determine the amount of water that could be saved by retrofitting devices to existing housing and installing devices during new construction. Two water conservation plans were developed. The moderate plan for residential water conservation would supply retrofit kits free of charge at convenient central distribution centers. Each kit, valued at approximately one dollar, would include toilet-tank bottles, shower flow-control inserts, and toilet leak-detection tablets. It is estimated that this plan for existing residences would save approximately 1.7 gallons per person per day (gpcd) applied to the entire existing residential population in the Bay Area. For new dwelling units, the plan would involve installation of low-flush toilets, shower flow controls, and faucet flow controls that could result in a savings of 16.6 gpcd applied to the future growth in population. This plan would cost approximately $30 for every new dwelling unit.

A reasonable maximum plan of residential water conservation for existing housing would use the same retrofit kit as the moderate plan, but would provide for the delivery of the kit free of charge door-to-door. Water savings achieved by this plan are estimated to be 4.1 gpcd. The reasonable maximum water conservation plan for new construction would require installation of low-flush toilets, shower flow controls, faucet flow controls, hot-water pipe insulation, thermostatic mixing valves, pressure regulators, drip irrigation systems, proper ground preparation for landscaping, and drought-tolerant plantings. The plan could result in water savings of 18.6 gpcd in inside use and 13 percent of outside use. The cost would be approximately $350 for each new dwelling unit.

Public education programs aimed at water conservation have been effective during the 1976-1977 drought. Primary emphasis has been placed on reducing unnecessary water use by changing personal habits, using more efficient devices and techniques, and modifying traditional western landscaping practices. It is estimated that

if these programs were to continue, an additional water savings of five percent could be obtained. A further reduction of five percent could be expected if a local water shortage in the Bay Area were publicized by the media.

Savings in the commercial sector are predicated upon continued application of the techniques used in the 1976-1977 drought, such as the use of toilet and faucet devices, recycling of water, and reduction of landscape irrigation. Savings in the industrial sector are based upon applying the same methods used for the commercial sector plus in-plant recycling of water, which was begun in earnest recently due to the drought and higher charges for municipal wastewater treatment. Water savings in these categories are expected to be in the range of five to 10 percent.

The effects of water conservation on municipal water use were evaluated on a county-by-county basis through the year 2000. The moderate plan for residential water conservation, combined with an additional five percent in all use categories due to public education and commercial water-use reductions, industrial water recycling, etc., would save approximately 124 mgd by the year 2000, which represents 8.8 percent of total municipal use. The maximum plan for residential water conservation plus a five percent savings in all categories would save 160 mgd by the year 2000, or 11.4 percent. These savings are lower (nine percent of total demand) in the slower growing counties and higher (14 percent of total demand) in the faster growing counties because the water conservation measures would be more effective in new construction.

Water consumption, on a per capita basis, is expected to increase through the year 2000 in nearly every county, even under the maximum water conservation plan. The expected increases under the maximum plan vary from small in the slower growing counties to over 25 percent in the faster growing areas. Without water conservation, the expected increases in per capita use would range from six to 37 percent. Consequently, conventional water use projections made using per capita coefficients might be inaccurate since they do not account for such factors as amount and density of new construction and declining household size.

Agricultural water conservation through improved irrigation efficiency would be effective in saving water. By conversion from less efficient irrigation practices to sprinkler or drip irrigation systems, savings of up to 30 percent could be achieved in some situations. Overall, a future savings of 15 percent could

be realized in the Bay Area. Agriculture is declining in the Bay Area due to the conversion of cropland to urban uses. Because urban uses require about the same amount of water per acre as irrigated agriculture, the conversion of agricultural land to urban uses would not affect total water supply requirements in the Bay Area.

WASTEWATER REUSE

Within the Bay Area there are approximately 40 existing and potential reclamation and reuse projects. In general, each of these involve advanced treatment at a sewage treatment plant for a portion of the wastewater and a distribution system to markets located usually less than 10 miles from the treatment plant. Presently, 15 mgd of reuse is on-line or under construction in the Bay Area. By 1980, the total reuse could be about 50 mgd and could increase by year 2000 to 152 mgd if all projects now in the preliminary planning stage are constructed. After 1990, approximately 20 percent of municipal wastewater could be reused if the market were fully developed. The projected reuse would be distributed approximately as follows: 43 percent to agricultural irrigation; 16 percent to landscape irrigation; 30 percent to industry; and 11 percent to other uses, such as groundwater recharge, marsh enhancement, and recreational lakes.

Many of the wastewater reuse projects identified in this study would make available a like amount of fresh water for another use. Approximately 70 percent of the projected reuse market volume would be effective in reducing demands for fresh water. This would result in a savings of 108 mgd, reducing the need for new water supplies by 5.5 percent in the year 2000.

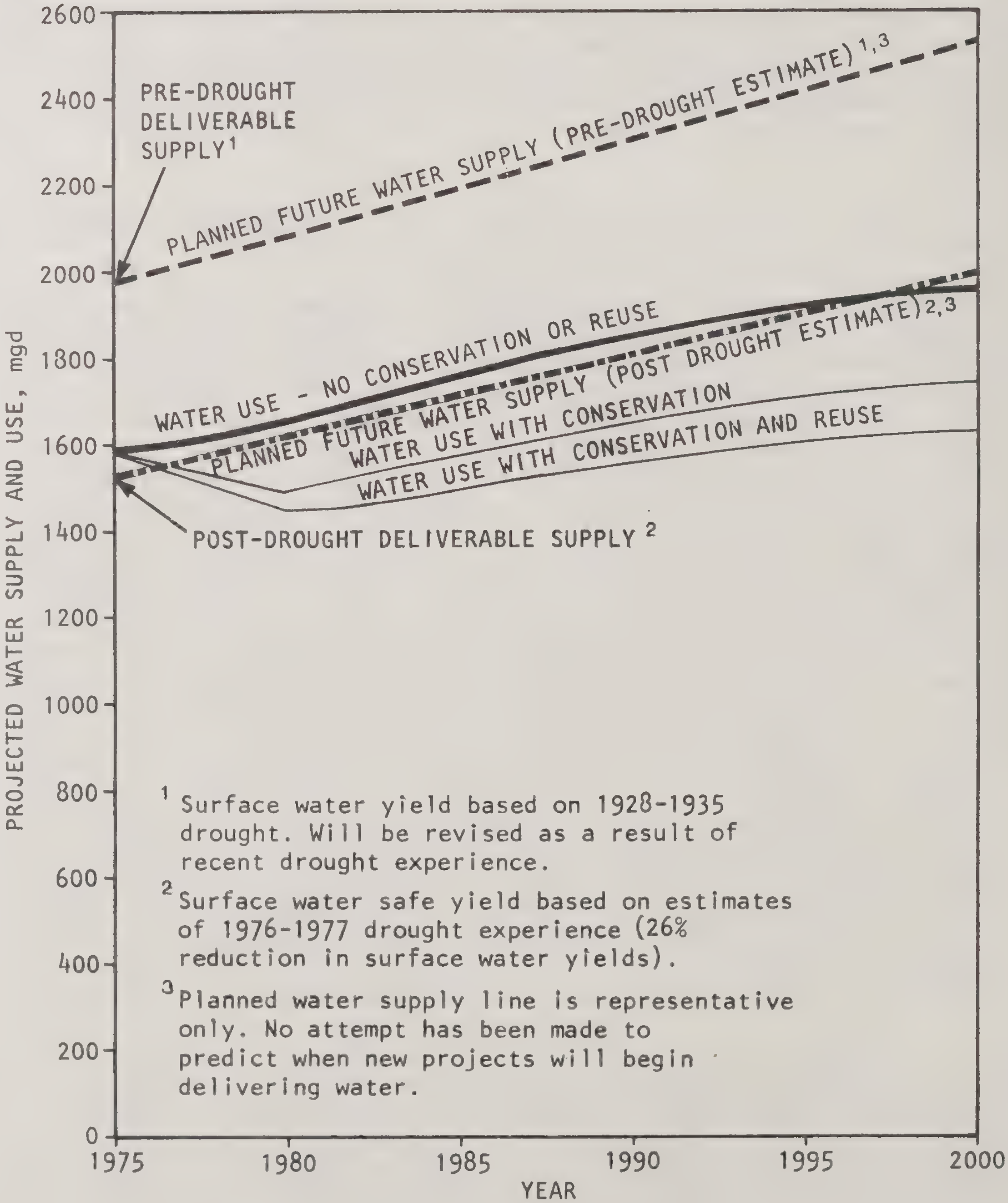
REGIONAL WATER RESOURCES ASSESSMENT

In 1975, the Bay Area had an apparent 18 percent reserve water supply. That is, the water supply agencies together could have supplied 18 percent more than was needed if a dry year, as occurred during the last drought (1928-1935), were to reoccur. Some portions of the Bay Area had a much larger reserve, such as 45 percent in the East Bay, while the Marin County-Sonoma County area had a five percent deficit. This latter area was able to meet demands in the early 1970's due to above average

rainfall but quickly developed a severe water shortage during the 1976-1977 drought. If all planned future water supply projects were built, the Bay Area reserve capacity in the year 2000, without water consevation, would be approximately 29 percent. Because some portions of the Bay Area would have a larger reserve than others, this reserve does not apply uniformly.

The drought of 1976-1977 has shown that pre-drought estimates of surface water yields were too high. During 1977, some reservoirs were nearly empty, groundwater tables fell at a rapid rate, State project water deliveries were cut 15 percent, and Federal project water deliveries were cut 50 percent (of the maximum entitlement) to municipal and industrial customers and 75 percent to agricultural customers. When the drought has ended, probably all surface water yields in California will be revised downward. Based on present indications, if 1978 is a normal rainfall year, surface water yields may be reduced on the order of 26 percent. If so, the future water supply for the Bay Area will become critical. Construction of all proposed water supply projects would not meet demand during a future drought of the same severity. By the year 2000 about half of the Bay Area would encounter a potential water shortage and the other half would have only about a 10 percent reserve. It is under these circumstances of reduced surface water yields that the benefits from water conservation and reuse become most apparent. Shown on Figure 2 is a comparison between projected future water use for the Bay Area and planned future water supplies. The pre-drought water supply curve is based upon 1975 information; the post-drought curve assumes a 26 percent reduction in surface water yields. The combination of new water supply projects and moderate water conservation would produce a Bay Area reserve of 15 percent using the pre-drought estimates of water supply. Implementation of all identified reuse markets would increase the Bay Area reserve to 20 percent. The amount of the reserve would range from six to 26 percent in the subregions of the Bay Area.

Other benefits can be derived from water conservation and reuse. If development of new sources of water supply can be postponed, savings will be effected in energy usage and in the cost of water. At present water rates, the retrofit program would, if the consumer had to buy the retrofit kit, be paid for in several months. The moderate plan for new construction would be amortized in four to five years.



BAY REGION
PROJECTED WATER USE AND ESTIMATE OF WATER SUPPLY

JBGA/WOM/RTC 10/77

FIGURE 2

The relative cost-effectiveness of conservation, reuse, and new supply were compared on a project-by-project basis. Conservation and reuse were considered to be cost-effective if their unit cost was less than the unit cost of developing the planned future water supply. From the comparison the following general conclusions were reached:

Development of new sources of water supplies will cost from 10¢ to 30¢/1,000 gallons ($33 to $97/acre-foot), assuming the project delivers the maximum designed amount of water.

Moderate municipal water conservation is the least expensive (4¢/1,000 gallons) method of generating new water supplies, i.e., reducing demands for new water supply.

Agricultural water conservation is generally less expensive than importing new water to the Bay Area.

Maximum water conservation would cost approximately 30¢/1,000 gallons, which in general is substantially more expensive than developing planned future sources of water supply.

Wastewater reuse projects would be economically comparable to new water supply source development if subsidized at existing State and Federal grant levels. Approximately 20 percent of the reuse projects would be the most cost-effective sources of new water supply if State and Federal construction grants were available.

INSTITUTIONAL AND FINANCIAL CONSIDERATIONS

Implementation of water conservation, reuse, and new supply projects, including the potential for water exchanges, would be greatly facilitated by better regional coordination. Solutions to individual problems may have regional impacts. To achieve better coordination, the formation of a new committee or group in the Bay Area is warranted. A Water Resource Management Coordinating Committee (WRMCC) should be formed to deal with all water-related activities and problems of a regional nature. The committee could be formed under a joint powers agreement or operate as an informal committee. Membership on the WRMCC could consist of the major water purveyors, wastewater dischargers, and approximately six smaller water and wastewater agencies. Staff support could be provided by ABAG or the member agencies. Functions of the WRMCC could include:

Development of an approach for water conservation to effect a permanent reduction in water use. The approach should capitalize on the current drought and use the regionally-oriented media.

Exploration of markets for reclaimed wastewater with emphasis on subregional and regional markets, i.e., those involving more than one wastewater discharger or water supply agency.

Development of a drought contingency plan for the Bay Area that could consider, as one option, water exchanges similar to those employed during the 1976-1977 drought.

The following financial aspects should be considered:

Methods should be developed to share the cost of water conservation among the beneficiaries. For example, a State income tax deduction for homeowners would provide an incentive for installation of water conservation devices.

Because agricultural water conservation is essentially a statewide issue, legislation will be needed to establish a reasonable plan and to deal with cost-sharing.

State and Federal construction grant funding priorities should be set among reuse projects; those which make existing water supply available for other existing uses should receive a higher priority than those which do not, especially if the service area is potentially water deficient.

The pricing provisions set forth in existing contracts between water wholesalers and water distribution agencies do not encourage water conservation. Consideration should be given to eliminating mimimum purchase requirements and substituting a flat rate plus a uniform charge up to the maximum entitlement.

CHAPTER I

INTRODUCTION

INTRODUCTION

The U. S. Environmental Protection Agency awarded a contract to the Association of Bay Area Governments (ABAG) to prepare an Environmental Management Plan for the San Francisco Bay Region under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. A Water Conservation, Reuse, and Supply Plan is one of seven management plans that will constitute the Environmental Management Plan. The other six elements of the Plan relate to surface runoff, air quality maintenance, municipal wastewater facilities, industrial discharges, nonpoint sources other than surface runoff, and solid waste.

Following completion of the seven individual plans, the relationships between them will be examined by ABAG and the plans adjusted as necessary.

OBJECTIVES OF THE STUDY

The general purpose of this study is to examine the issues of water conservation and reuse, project their effect on water supply needs and wastewater generation rates, and develop the basis for a water resources plan for the San Francisco Bay Region.

Specific objectives of the study are to:

1. Collect information on water supply agencies in the Bay Area;
2. Project water demands for the Bay Area;
3. Develop water conservation measures;
4. Identify reuse markets for reclaimed wastewater;
5. Delineate wastewater reclamation and reuse alternatives;

6. Formulate subregional and regional water resource alternatives;

7. Assess and evaluate water resource alternatives; and

8. Assist in regional compilation, adjustment, and assessment.

This report addresses the first seven objectives; the eighth will be accomplished during integration of the results contained in this report with the six other individual plans into the development of the Environmental Management Plan.

SCOPE OF STUDY

The San Francisco Bay region, or Bay Area, consists of nine counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. The total land area of the region is 7,000 square miles.

The 208 Study Area is based upon watershed boundaries and is smaller than the nine-county Bay Area. It includes all of Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara counties, most of Marin County, about a half of Napa and Solano counties, and about a fourth of Sonoma County.

The area used in this study was the entire nine-county Bay Area, not the 208 Study Area. This was necessary to provide consistency between two of the major water resource elements--water supply and water use--evaluated in this study. ABAG's population, housing, employment, and land-use projections were developed for the total nine-county Bay Area, and although these data were available for 440 individual zones within the area, some of the zones were split by the 208 Study Area boundary in Marin, Napa, Solano, and Sonoma counties. Also, some major water supply agency service areas extended outside of the 208 Study Area in several of these counties, making it extremely difficult to determine the relative allocation of water between the two areas.

CONDUCT AND ORGANIZATION OF THE STUDY

The study, initiated in October 1976, was performed and the report prepared by J. B. Gilbert & Associates, under contract with ABAG. Dr. Donald L. Feuerstein was project manager and William O. Maddaus was the project engineer. Overall direction was provided by Jerome B. Gilbert. Other staff of J. B. Gilbert & Associates participating in this study were John R. Monser, Dr. Aaron Meron, Charles P. Lockwood, and Jane K. Powers. John O. Nelson, under subcontract to J. B. Gilbert & Associates, provided consultation and assistance in the water conservation elements of the study.

ACKNOWLEDGMENTS

Many individuals contributed to the study; without their assistance the conduct of the study would have been most difficult and the results less representative of the real state of affairs in the Bay Area.

On the ABAG staff, B. J. Miller, coordinator of the 208 Program, and particularly John A. Davis, provided overall guidance to the study and necessary coordination with other elements under development for the Environmental Management Plan. Their contributions and support during the conduct of the study are gratefully acknowledged.

Special mention is due numerous personnel from the East Bay Municipal Utility District who provided detailed information on water use in their service area.

All of the members of the Technical Advisory Committee, representing the major water suppliers and water distribution agencies in the Bay Area, provided invaluable review of activities and results during the study; their assistance is most appreciated.

Many of the water purveyors in the Bay Area were contacted and provided substantive data and information; their cooperation is gratefully acknowledged.

CHAPTER II

WATER SUPPLY IN THE BAY AREA

INTRODUCTION

In the early stages of development in the Bay Area, communities relied upon local surface water and groundwater for their supplies. These sources eventually became inadequate, however, and the Bay Area began supplementing the local sources with surface water developed outside the Bay Area. In many cases these sources were of superior water quality; and as a consequence, many of the local sources were abandoned or used on a standby basis only. At the present time, slightly more than one-half of the water used in the Bay Area is imported surface water. Groundwater basins in the Bay Area have been extensively developed and in some cases their safe yields have been exceeded for a number of years, leading to a decline in the local water tables.

The extent and utilization of existing sources of water supply, and the potential capacity or entitlement to other sources of water, is documented in this chapter. Information on the water wholesalers and the water distribution agencies is presented in graphical form, and data characterizing municipal-industrial water use within each distribution agency's service area are tabulated. This latter source of data formed the basis for the water use projections presented in Chapter IV. Information on the water used by agriculture for irrigation is also presented.

WATER SUPPLY SOURCES

Water is supplied to the nine-county Bay Area from eight separate sources or systems. These sources and the quantity of water they supply to each of the nine counties in the Bay Area are presented in Table II-1.

For the Bay Area in 1975-1976, the largest (27 percent) source of supply was local groundwater, followed by the Hetch Hetchy system (17 percent). The Delta and Lake Berryessa each supplied 13

TABLE II-1

WATER SUPPLY TO COUNTIES IN THE BAY AREA FOR
AGRICULTURAL AND MUNICIPAL-INDUSTRIAL USE
(1975-1976)

County	Source	Quantity	
		mgd	% of Total
Alameda	Hetch Hetchy and Local Reservoirs	31	14
	EBMUD-Mokelumne	112	52
	EBMUD-Terminal Reservoirs	6	3
	South Bay Aqueduct	16	8
	Niles Cone Groundwater	27	12
	Livermore-Amador Groundwater	24	11
	Subtotal	216	100
Contra Costa	EBMUD-Mokelumne	78	30
	EBMUD-Terminal Reservoirs	14	5
	Contra Costa Canal-Delta	60	23
	East Contra Costa County-Delta	105	40
	Groundwater	5	2
	Subtotal	262	100
Marin	Russian River	8	21
	Marin County Reservoirs	28	74
	Groundwater	2	5
	Subtotal	38	100
Napa	Lake Berryessa	10	28
	Napa County Reservoirs	17	47
	Groundwater	9	25
	Subtotal	36	100
San Francisco	Hetch Hetchy and Local Reservoirs	98	100
San Mateo	Hetch Hetchy and Local Reservoirs	89	84
	San Mateo Reservoirs	5	5
	Groundwater	12	11
	Subtotal	106	100

TABLE II-1
(Continued)

WATER SUPPLY TO COUNTIES IN THE BAY AREA FOR
AGRICULTURAL AND MUNICIPAL-INDUSTRIAL USE
(1975-1976)

County	Source	Quantity	
		mgd	% of Total
Santa Clara	Hetch Hetchy and Local Reservoirs	54	14
	South Bay Aqueduct	105[a]	28
	Santa Clara County Reservoirs	35[b,c]	10
	Groundwater	179[c]	48
	Subtotal	373	100
Solano	Lake Berryessa	190	51
	Cache Slough-Delta	48	13
	Solano County Reservoirs	3	1
	Groundwater	132	35
	Subtotal	373	100
Sonoma	Russian River	44	48
	Groundwater	48	52
	Subtotal	92	100
Bay Region	Hetch Hetchy and Local Reservoirs	272	17
	Mokelumne	190	12
	South Bay Aqueduct	121	8
	Russian River	52	3
	Lake Berryessa	200	13
	Delta	213	13
	Local Reservoirs	108	7
	Groundwater	438	27
	Total	1,594	100

[a]35 percent used for groundwater recharge
[b]60 percent used for recharge
[c]Fiscal year 1974-1975

percent, the Mokelumne system delivered 12 percent, the South Bay Aqueduct supplied eight percent, local reservoirs (local surface runoff) provided seven percent, and the Russian River supplied the remaining three percent.

The Hetch Hetchy system, built and operated by the City and County of San Francisco, consists of three reservoirs on the Tuolumne River watershed--Hetch Hetchy, Lake Eleanor, and Lake Lloyd--and the Hetch Hetchy Aqueduct, which extends about 135 miles from the Tuolumne River to Crystal Springs Reservoir located in San Mateo County.

The Mokelumne system, built and operated by the East Bay Municipal Utility District, consists of Pardee Reservoir and Camanche Reservoir, developed on the Mokelumne River, and the Mokelumne Aqueduct, which transports water to terminal reservoirs in western Contra Costa County and Alameda County.

The South Bay Aqueduct, a system of the State Water Project, diverts water from the California Aqueduct near Tracy and delivers water as far west as San Jose.

The Russian River system, built and operated by the Sonoma County Water Agency, consists of diversion structures located near Guerneville and aqueducts leading to the City of Santa Rosa, the Sonoma Valley, the City of Petaluma, and northern Marin County.

Lake Berryessa, located in northeastern Napa County, is part of the Solano Project, which was developed and is operated by the United States Bureau of Reclamation.

The locations of water supply sources for the Bay Area are shown on Figure II-1.

WATER SUPPLY HIERARCHY

For purposes of this study, the Bay Area has been divided geographically into five subregions, based upon where each subregion derives its water supply. These subregions and their constituents are as follows:

Peninsula subregion	San Francisco and San Mateo counties
South Bay subregion	Santa Clara County
East Bay subregion	Alameda and Contra Costa counties

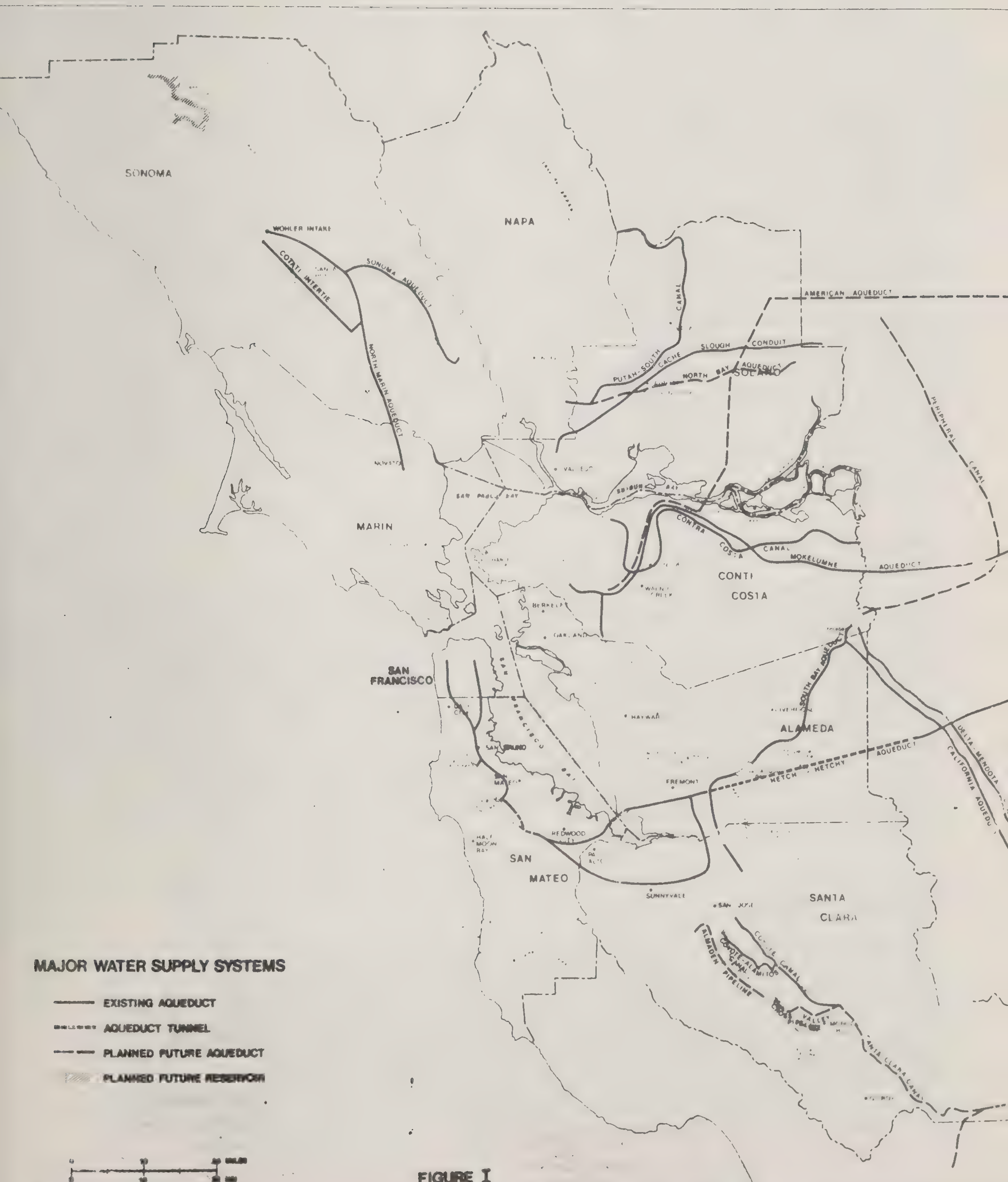


FIGURE I

Source: J. B. Gilbert & Assoc.; Cartography by ABAG, 1977.

Napa-Solano subregion	Napa and Solano counties
Marin-Sonoma subregion	Marin and Sonoma counties

Peninsula Subregion

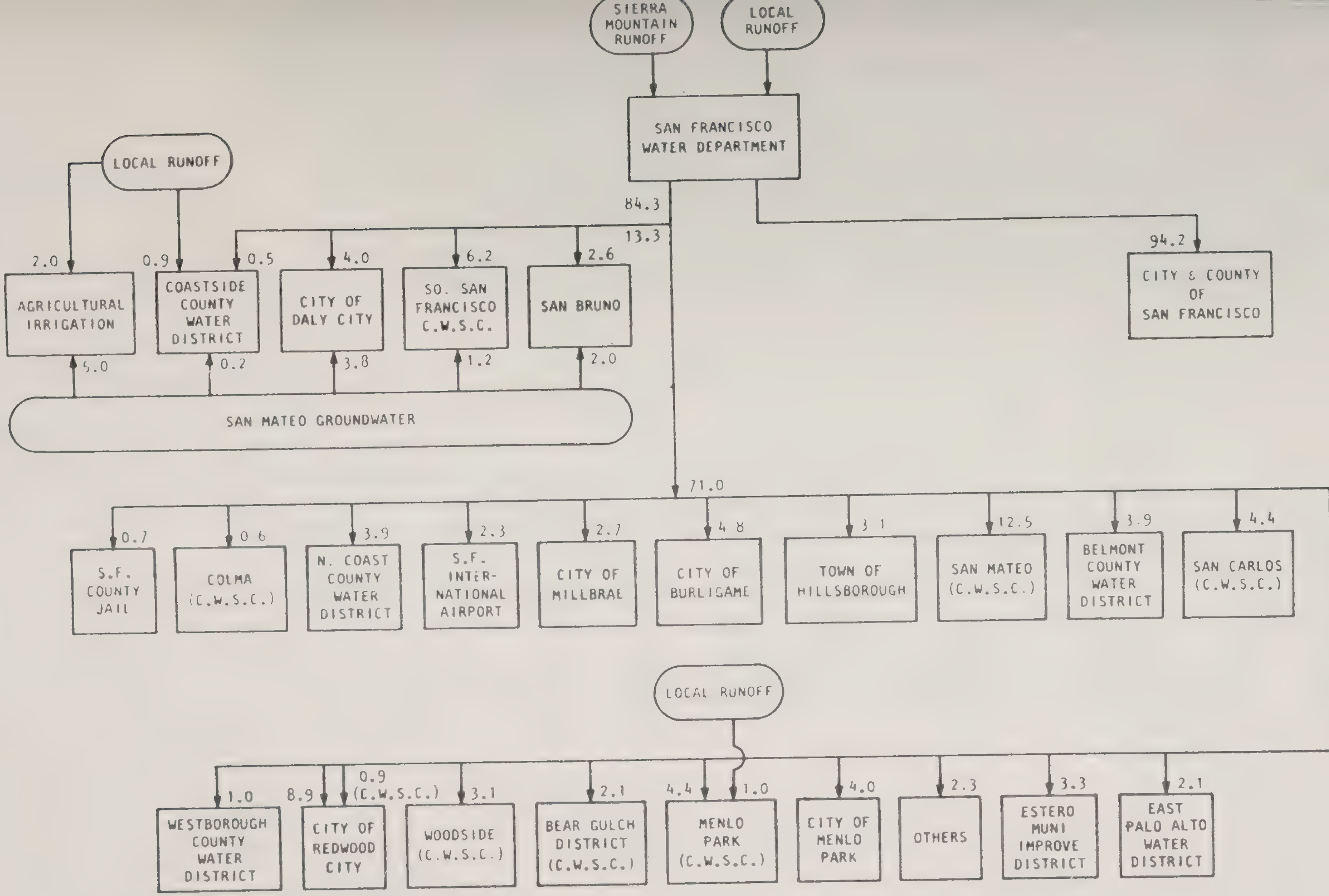
The Peninsula subregion relies almost entirely upon the San Francisco Water Department's Hetch Hetchy system for its water supply. As shown on Figure II-2, water is supplied to 22 agencies, who distribute the water to the various cities and districts in San Mateo County and the City of San Francisco. A few agencies also rely upon groundwater and local surface water. San Francisco derives all of its supply from the Hetch Hetchy system and local reservoirs. San Mateo County obtains 84 percent of its water from the Hetch Hetchy system, 11 percent from groundwater, and five percent from local reservoirs (see Table II-1).

South Bay Subregion

The South Bay subregion is served by two major water importation systems--the South Bay Aqueduct and the Hetch Hetchy system--as shown on Figure II-3. The South Bay Aqueduct is now a major source of supply for the Santa Clara Valley Water District, a major wholesaler of water. The Hetch Hetchy system supplies water to 10 cities and agencies in northern Santa Clara County. In the South Bay subregion, it is common for agencies to have two sources of supply, and sometimes, three sources. Santa Clara County obtains about half of its water from groundwater, 28 percent from the South Bay Aqueduct, 14 percent from the Hetch Hetchy system, and 10 percent from local reservoirs (see Table II-1).

East Bay Subregion

As shown on Figure II-4, the East Bay subregion obtains its water from four sources: The Sacramento-San Joaquin Delta; the Mokelumne system; the South Bay Aqueduct; and the San Francisco Water Department's Hetch Hetchy system. A small amount of water is obtained from local reservoirs and groundwater. In 1975, East Bay Municipal Utility District supplied one-half of the water used in Alameda County and one-third of the water used in Contra Costa County. The South Bay Aqueduct is a major source of water for Zone 7 of the Alameda County Flood Control and Water

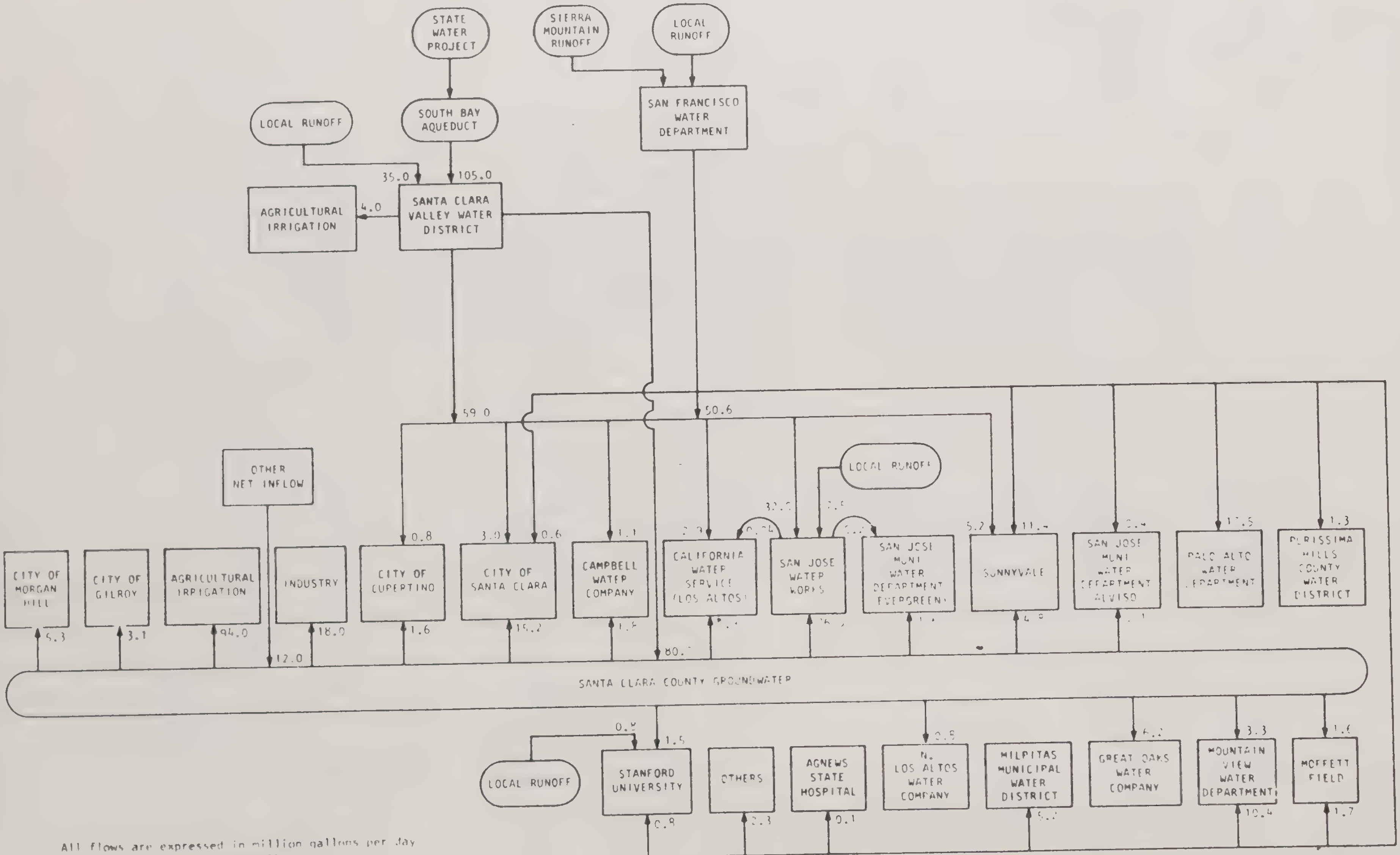


C.W.S.C. = California Water Service Company

All flows are expressed in million gallons per day and represent average annual flows.

PENINSULA WATER SUPPLY HIERARCHY
1975-1976

JBGA/WOM/RTC 9/77 FIGURE II-2

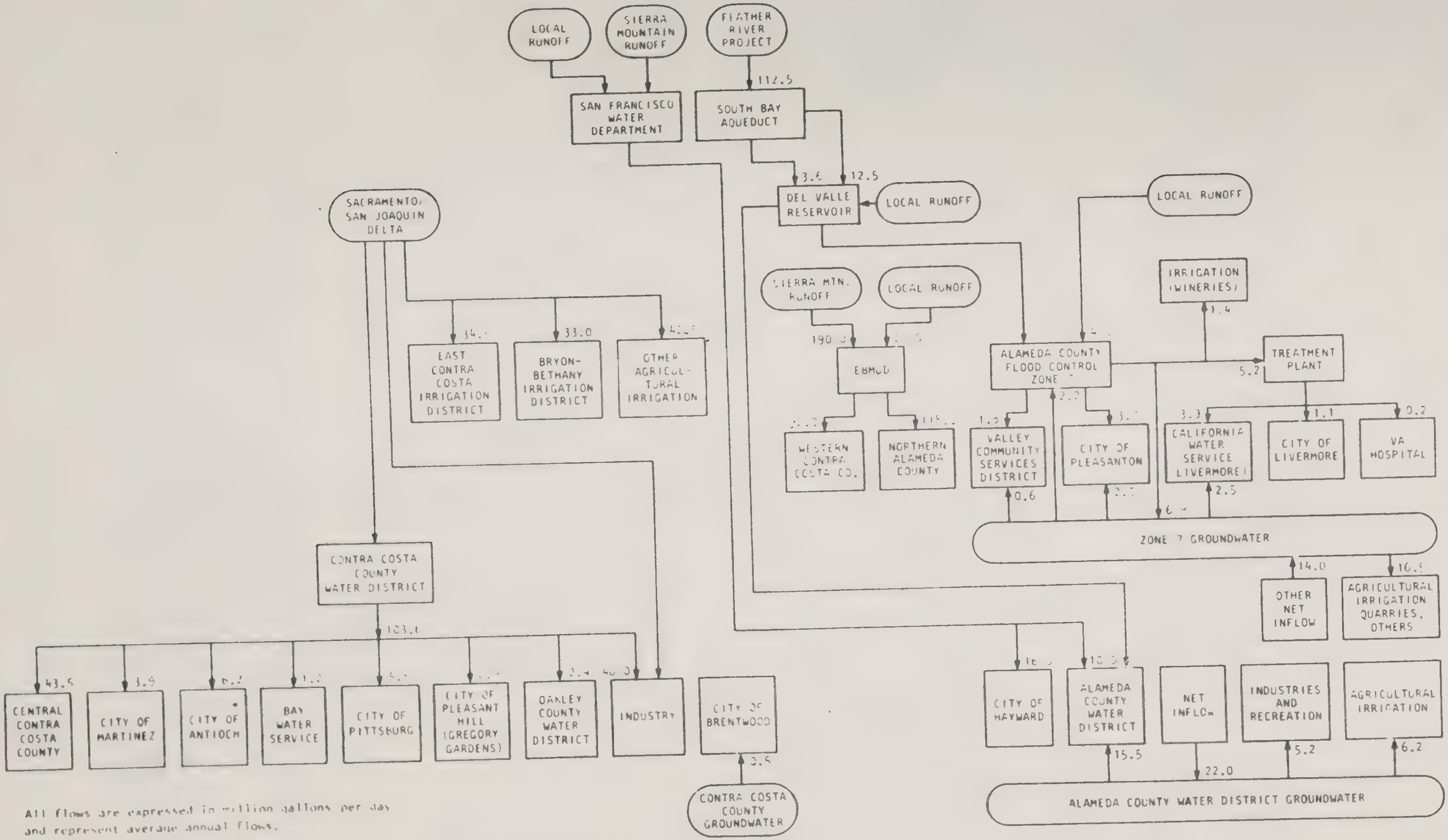


All flows are expressed in million gallons per day and represent average annual flows.

SOUTH BAY WATER SUPPLY HIERARCHY
1975-1976

JBGA/WOM/RTC 9/77

FIGURE II-3



EAST BAY WATER SUPPLY HIERARCHY
1975-1976
JBGA/WOM/RTC 9/77 FIGURE II-4

Conservation District and the Alameda County Water District. The latter agency also buys water from the San Francisco Water Department. The Contra Costa County Water District sells treated water to Central Contra Costa County and raw water via the Contra Costa Canal to six cities and agencies and several industries which also draw water directly from the Delta when the water quality is acceptable.

Marin-Sonoma Subregion

The Marin-Sonoma subregion water supply hierarchy is shown on Figure II-5. The Russian River is the primary source of water in this subregion, except for southern and central Marin County, which derives its water from several local reservoirs. In Sonoma County, groundwater is a supplemental source of water for some cities and a major source for agriculture. The Russian River supplies 21 percent of the water in Marin County; 79 percent is derived from local sources (see Table II-1). In Sonoma County the Russian River supplies 48 percent of the water, with the balance coming from groundwater.

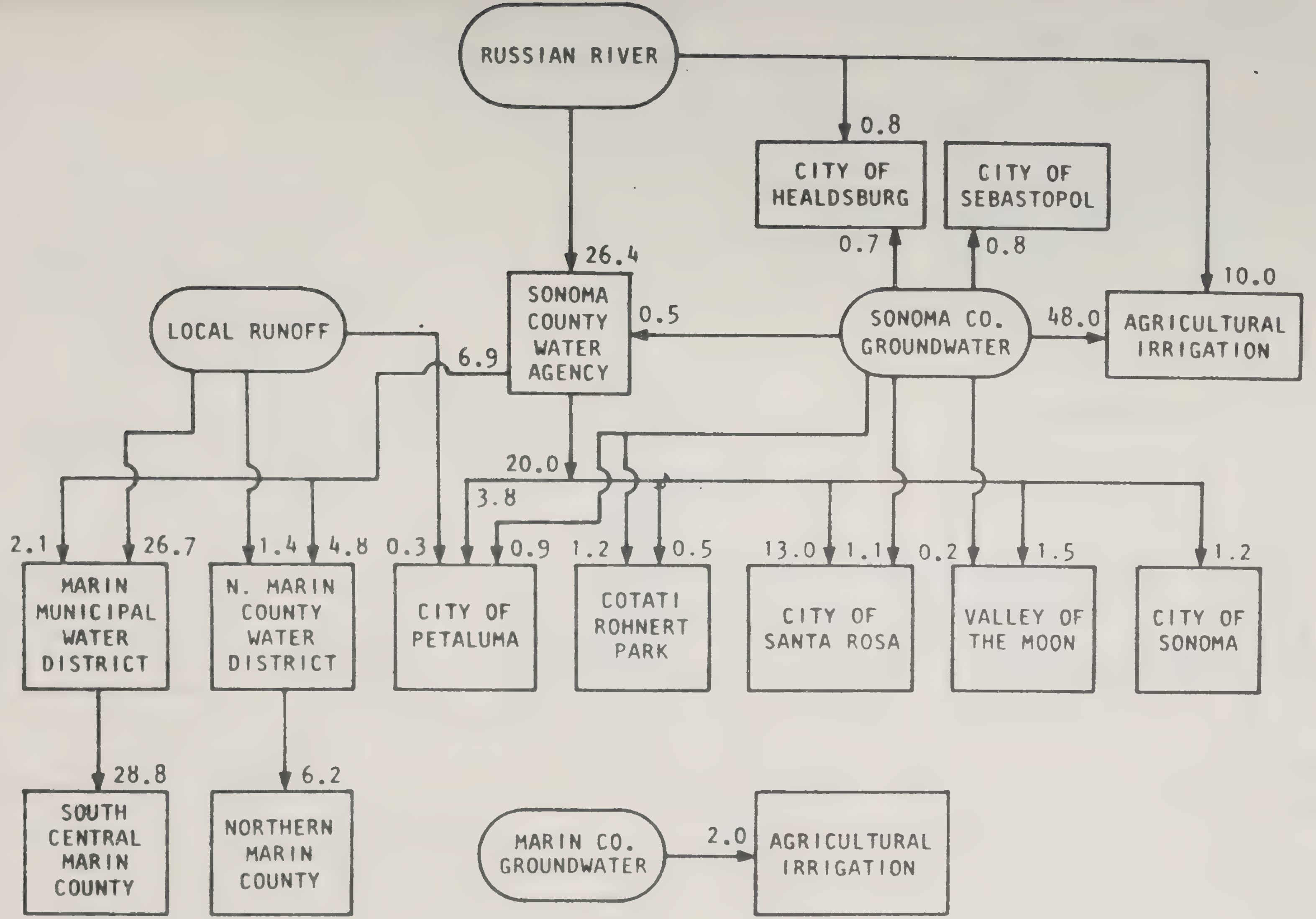
Napa-Solano Subregion

In the Napa-Solano subregion the largest source of water is Lake Berryessa. Local reservoirs and groundwater in Napa County supply the remainder of the water, as shown on Figure II-6. The Solano County Flood Control and Water Conservation District wholesales water to irrigation districts and six cities or agencies in Napa County. Groundwater is a major source of water supply in Solano County, currently supplying 35 percent of its needs (see Table II-1). Cache Slough and other sloughs which divert water from the Delta supply 13 percent of Solano County's water use.

Water Distribution Agencies

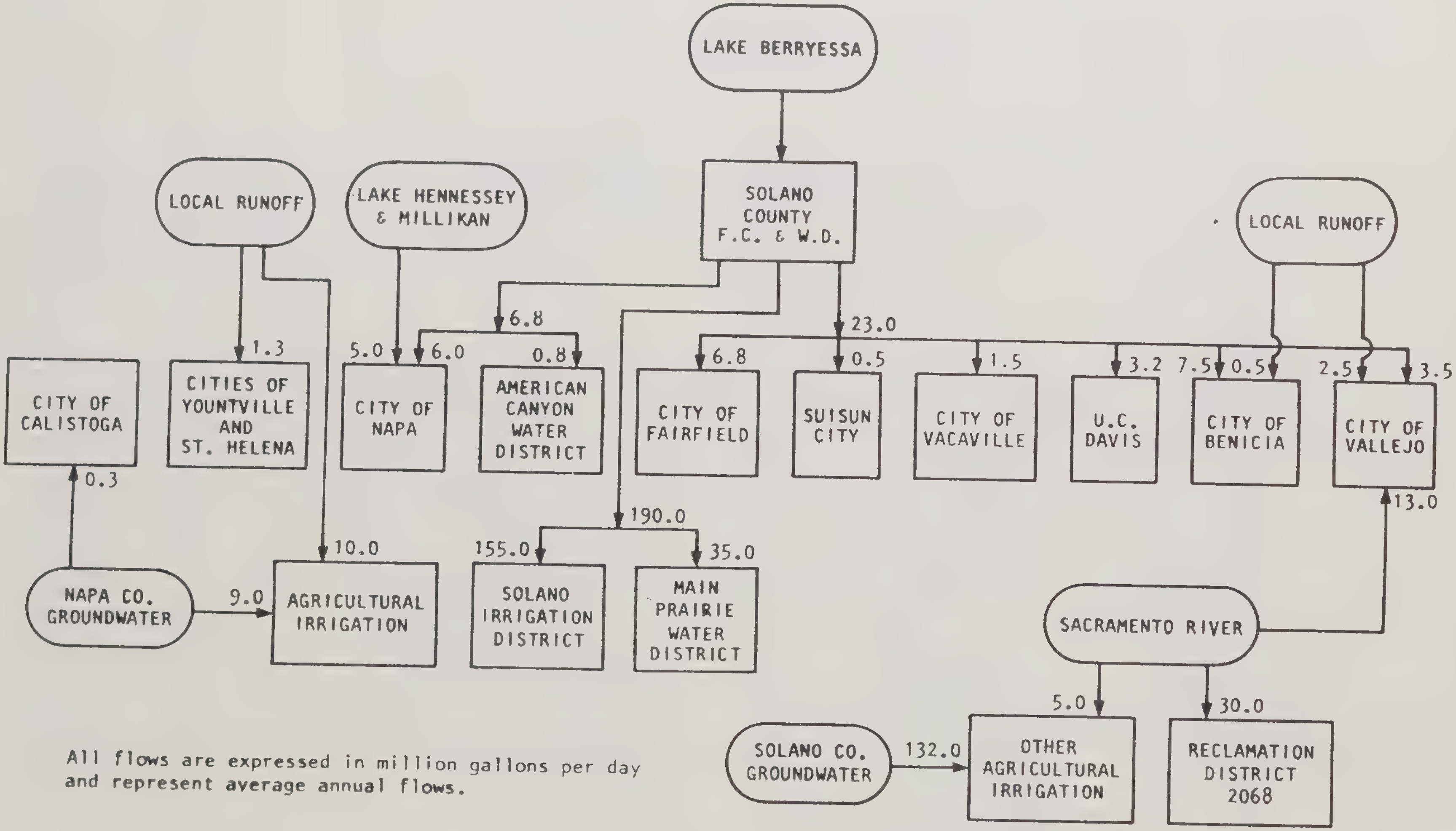
Municipal and Industrial Water Supply. In the nine-county Bay Area, municipal and industrial water requirements are met by 83 distribution agencies, which are listed in Table II-2.

One agency, East Bay Municipal Utility District, distributes water in two counties and one water company, California Water Service Company, distributes water in three counties. Therefore there are 80 different water distribution agencies in the



All flows are expressed in million gallons per day and represent average annual flows.

MARIN-SONOMA WATER SUPPLY HIERARCHY
1975-1976
JBGA/WOM/RTC 9/77 FIGURE II-5



All flows are expressed in million gallons per day and represent average annual flows.

NAPA-SOLANO WATER SUPPLY HIERARCHY
1975-1976

JBGA/WOM/RTC 9/77 FIGURE II-6

TABLE II-2

WATER DISTRIBUTION AGENCIES IN THE BAY AREA AND CURRENT WATER USE[a]
(mgd)

Agency Name	Approximate Population Served	Residential	Commercial-Industrial	Public Authority	Unaccounted-for	Total
Alameda County						
1 Alameda County Water District[b]	179,000	--	--	--	--	25.70
2 California Water Service Company[b]	49,000	--	--	--	--	6.36
3 Citizens Utility Company of California[b]	13,000	--	--	--	--	1.30
4 East Bay Municipal Utility District[b]	1,028,000[c]	64.19	35.89	6.13	11.95	118.16
5 Hayward, City of[b]	79,200	--	--	--	--	16.03
6 Livermore, City of[b]	4,500	--	--	--	--	0.49
7 Pleasanton, City of[b]	36,700	--	--	--	--	5.72
8 Valley Community Services District[b]	15,000	--	--	--	--	2.34
Contra Costa County						
40 Antioch, City of[b]	34,800	4.56	1.20	0.17	0.22	6.15
41 Bay Water Service System of Southern California Water Company	6,500	--	--	--	--	1.19
42 Brentwood, City of	2,500	--	--	--	--	0.39
43 Contra Costa County Water District[b]	140,500	--	--	--	--	43.49
44 East Bay Municipal Utility District[b]	1,028,800[c]	42.42	39.17	0.0	8.43	90.02
45 Martinez, City of[b]	26,200	--	--	--	—	3.94
46 Pittsburg, City of[b]	26,900	3.24	1.66	0.39	0.27	5.56
47 Pleasant Hill, City of (Gregory Gardens)[b]	5,600	--	--	--	--	0.93
Marin County						
48 Coast Springs Water Company	600	--	--	--	--	0.01
49 Marin Municipal Water District[b]	169,382	18.38	5.34	2.44	2.65	28.81
50 North Marin County Water District[b]	40,750	5.18	0.37	0.25	0.37	6.17
51 Stinson Beach Water Company	1,500	--	--	--	--	0.14
Napa County						
9 American Canyon County Water District[b]	5,600	--	--	--	--	0.80
10 Calistoga, City of	1,875	--	--	--	--	0.27
11 Napa, City of[b]	56,700	6.59	2.39	0.67	1.05	10.70
12 St. Helena, City of	4,000	--	--	--	--	1.24
13 Yountville, City of	1,000	--	--	--	--	0.08
San Francisco						
14 San Francisco, City of[b]	665,000	35.07	50.23	4.33	4.61	94.24
San Mateo County						
52 Belmont County Water District[b]	25,200	--	--	--	--	3.87
53 Brisbane, City of[b]	2,000	--	--	--	--	0.28
54 Burlingame, City of[b]	30,600	--	--	--	--	4.79
55 California Water Service Company[b]	216,100	--	--	--	--	33.68
56 Citizens Utility Company	2,000	--	--	--	--	0.28
57 Coastside County Water District	8,600	--	--	--	--	1.60
58 County Service Area No. 7	945	--	--	--	--	0.06
59 Daly City	50,500	--	--	--	--	7.8
60 Diamond Public Utility District[b]	1,400	--	--	--	--	0.26
61 East Palo Alto County Waterworks District	13,700	--	--	--	--	2.10
62 Estero Municipal Development District[b]	21,500	--	--	--	--	3.30

TABLE II-2
(Continued)

WATER DISTRIBUTION AGENCIES IN THE BAY AREA AND CURRENT WATER USE[a]
(mgd)

Agency Name	Approximate Population Served	Residential	Commercial-Industrial	Public Authority	Unaccounted-for	Total
San Mateo County (Continued)						
64 Hillsborough, Town of[b]	20,100	--	--	--	--	3.09
65 Los Trancos County Water District[b]	400	--	--	--	--	0.05
66 Menlo Park, City of[b]	25,900	--	--	--	--	3.98
67 Millbrae, City of[b]	17,600	--	--	--	--	2.73
68 North Coast County Water District[b]	25,200	--	--	--	--	3.92
69 O'Connor Tract Cooperative Water Company	1,800	--	--	--	--	0.25
70 Palo Alto Park Mutual Water Company	2,100	--	--	--	--	0.41
71 Palomar Park County Waterworks District	600	--	--	--	--	0.08
72 Redwood City	63,900	--	--	--	--	9.80
73 San Bruno, City of	29,900	--	--	--	--	4.60
74 Skyline County Water District[b]	700	--	--	--	--	0.10
75 Westborough County Water District[b]	6,200	--	--	--	--	0.95
Santa Clara County						
15 California Water Service Company[b]	56,300	--	--	--	--	9.85
16 Campbell Water Company	15,900	--	--	--	--	2.79
17 Cupertino, City of	12,000	--	--	--	--	2.4
18 Gilroy, City of[b]	16,400	--	--	--	--	3.06
19 Great Oaks Water Company, Inc.[b]	35,300	--	--	--	--	6.18
20 Magic Sands Mobile Home Park	600	--	--	--	--	0.04
21 Milpitas, City of[b]	31,130	--	--	--	--	5.18
22 Morgan Hill, City of	--	--	--	--	--	--
23 Mountain View, City of[b]	66,600	7.70	4.70	0.65	0.65	13.70
24 Palo Alto, City of[b]	65,400	7.70	6.60	2.50	0.78	17.58
25 Purissima Hills Water Company[b]	6,300	--	--	--	--	1.30
26 Redwood Mutual Water Company	1,300	--	--	--	--	0.05
27 San Jose, City of	10,800	--	--	--	--	1.89
28 San Jose Highlands Water Comapny	645	--	--	--	--	0.05
29 San Jose Waterworks[b]	635,000	65.85	32.17	8.76	9.43	116.21
30 Santa Clara, City of[b]	90,500	--	--	--	0.9	18.81
31 Saratoga Heights Mutual Water Company	375	--	--	--	--	0.05
32 Stanford University	17,700	--	--	--	--	3.10
33 Sunnyvale, City of[b]	106,800	11.28	9.00	0.0	1.29	21.57
Solano County						
34 Benicia, City of	8,000	--	--	--	--	8.00
35 Fairfield, City of[b]	44,000	--	--	--	--	6.75
36 Rio Vista, City of	--	--	--	--	--	--
37 Suisun City	4,150	--	--	--	--	0.57
38 Vacaville, City of	35,000	--	--	--	--	1.50
39 Vallejo, City of[b]	119,000	--	--	2.89	--	18.31
Sonoma County						
76 Cloverdale, City of	--	--	--	--	--	--
77 Cotati Public Utility District	2,830	--	--	--	--	--
78 Forestville County Water District	2,785	--	--	--	--	0.22
79 Healdsburg, City of[d]	6,000	--	--	--	--	1.48
80 Petaluma, City of[b]	34,154	3.71	0.50	0.37	0.44	5.02
81 Rohnert Park, City of	--	--	--	--	--	--

TABLE II-2
(Continued)

WATER DISTRIBUTION AGENCIES IN THE BAY AREA AND CURRENT WATER USE[a]
(mgd)

Agency Name	Approximate Population Served	Residential	Commercial-Industrial	Public Authority	Unaccounted-for	Total
Sonoma County (Continued)						
82 Santa Rosa, City of[b]	72,920	--	--	--	--	14.10
83 Sebastopol, City of[d]	4,800	--	--	--	--	0.81
84 Sonoma, City of	7,132	--	--	--	--	1.23

[a]All data refer to 1970, except as noted

[b]1975-1976 data

[c]Alameda and Contra Costa counties combined

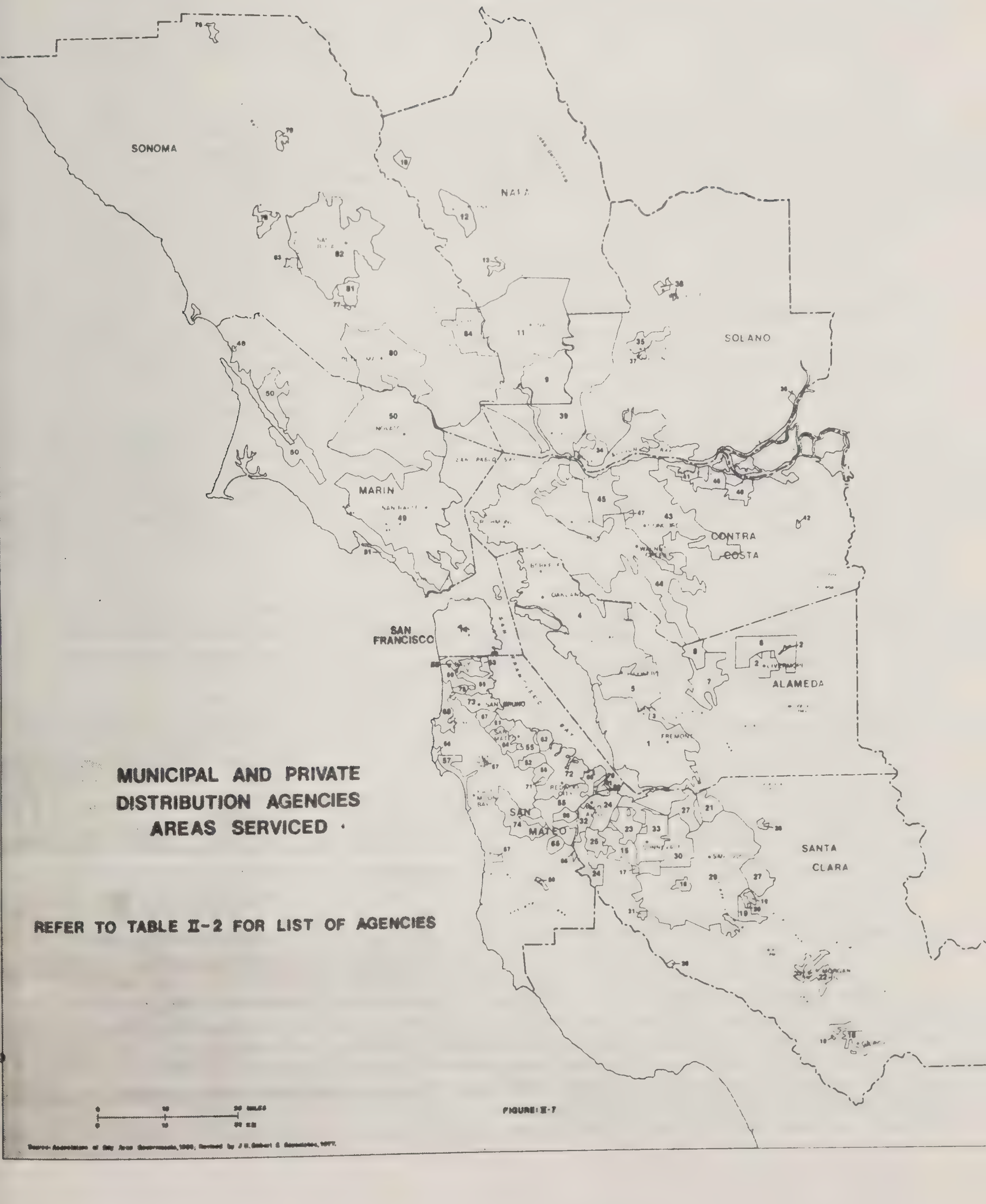
[d]Mean of 1971-1975

nine-county Bay Area. San Mateo County has the most distribution agencies with 22, followed by Santa Clara County with 18. Only San Francisco has one water distribution agency; and Marin, Napa, and Solano counties have six or less agencies. About half, or 40, of the agencies are cities, 19 are special water districts or utility districts, and the remaining 22 of the agencies are private companies.

The approximate population served by each agency is also shown in Table II-2. Water-use data for 1975 were obtained from 45 agencies. These agencies supply approximately 85 percent of all municipal and industrial water in the Bay Area. Only fresh water supply was considered in this study; hence the relatively large volumes of San Francisco Bay water used for power plant and industrial cooling were excluded from consideration. The 1970 data listed in Table II-2 were obtained from the Water Quality Control Plan, San Francisco Bay Basin (2)[Reference 1]. Where information was available, total water use was divided into residential, commercial-industrial, public authority, and unaccounted-for. A further breakdown of the commercial-industrial category into separate commercial and industrial uses could not be done on a consistent basis in the Bay Area because each water distribution agency defines industry and commercial establishments differently. In some cases only manufacturing companies are classified as industrial, whereas others extend the industrial classification to activities such as transportation, printing, and institutional services. The service area boundary of each water distribution agency is shown on Figure II-7. The entire urbanized portion of the Bay Area is served by water distribution agencies. Private wells provide water supply for water users outside these areas.

Agricultural Water Supply. Surface water is distributed to individual farms by irrigation districts in only four counties in the Bay Area. A list of these water agencies is presented in Table II-3, together with, where available, the irrigated acreage in the district and the amount of water used for crop irrigation in 1975. When the supply is groundwater and a particular water agency is responsible for managing the groundwater basin, including groundwater recharge, agricultural pumping is regulated either by permits or metering.

In addition to the agricultural water supplied by the various districts, water is pumped by the irrigator and directly applied. As no records are kept of these withdrawals, only an estimate of the water used can be made. For completeness



MUNICIPAL AND PRIVATE DISTRIBUTION AGENCIES AREAS SERVICED

REFER TO TABLE II-2 FOR LIST OF AGENCIES

FIGURE: II-7

these estimates are included with the agricultural water use on Figures II-2 through II-6. The procedure used in making these estimates is presented in Chapter IV, together with the agricultural water-use projections through the year 2000.

TABLE II-3

WATER SUPPLIED BY AGRICULTURAL WATER SUPPLY AGENCIES (1975)

Agency Name	Irrigated Acreage	Water Use acre-ft
Alameda County		
Alameda County Water	--	7,000
Alameda County Flood Control and Water Conservation District Zone 7	--	10,000
Contra Costa County		
East Contra Costa County Irrigation District	15,000	39,000
Bryn-Bethany Irrigation District	10,850	37,400
Santa Clara County		
Santa Clara Valley Water District	8,200	21,800
Solano County		
Solano Irrigation District	51,000	175,100
Main Prairie Water District	12,000	33,000
Reclamation District No. 2068	--	39,700

EXISTING AND POTENTIAL SOURCES OF SUPPLY

For every developed surface water supply, a contract between the wholesaler and the distributor exists specifying the minimum and maximum utilization of this source of supply. Generally the amount used in 1975-1976 was below the maximum entitlement. For groundwater supply, the cumulative effects of all municipal-industrial and agricultural pumping on a particular groundwater aquifer may or may not exceed the safe yield, which translates to

the annual average maximum entitlement. Most of the major aquifers are managed by a water district that can levy charges on pumping but cannot specify maximum withdrawals.

To put the water demands into perspective, knowledge of maximum entitlements to surface and groundwater are necessary to evaluate future water supply. Some water districts have planned major new water supply projects to meet anticipated growth in water demands based on their projections. These projects have been re-evaluated on the basis of projected water demands developed in this study.

All existing and future water sources currently being used or proposed for use in the Bay Area are presented in Table II-4. This table indicates the amount of water received by each county in 1975-1976, the water that could be delivered from this source, and the maximum entitlement based upon contracted amounts or safe yields of the source. Each of the projects are discussed in the subsequent text, which has been organized by the principal water district responsible for developing the particular source of water.

Peninsula Subregion

San Francisco Water Department. The San Francisco Water Department (SFWD) operates the largest water supply system in the Bay Area, serving over 37 percent of the Bay Area population. Local sources of water, which include five reservoirs with a total storage capacity of 77,930 acre-feet and the Sunol Filter Galleries, are listed in Table II-5. The estimated minimum safe annual yield is 39,600 acre-feet. In 1975-1976, the SFWD drew 5,900 acre-feet from this source.

Table II-5 also lists the Sierra reservoirs and their storage capacity and minimum safe annual yield. Not listed in Table II-5 are three small reservoirs used for flow regulation in the diversion structures. When all reservoirs in the Sierras are full, the SFWD has over 1.2 million acre-feet in storage. Don Pedro Reservoir was completed in 1970 for flood control and for agricultural water supply to the Modesto and Turlock Irrigation districts. These two districts have prior entitlements to the water in the Tuolumne River. The SFWD owns approximately one-fourth of the storage in Don Pedro Reservoir, but this water must be released to these irrigation districts. Construction of Don Pedro Reservoir enabled the upstream SFWD reservoirs to be used more efficiently for the SFWD water supply with less emphasis on flood control and on meeting downstream water

TABLE II-4

SURFACE WATER AND GROUNDWATER SUPPLY
SOURCES FOR THE BAY AREA
(mgd)

Source (Wholesaler)	Counties Served	Supplied in 1975-76	Existing Deliverable[a]	Ultimate Available[a]
Hetch Hetchy (SFWD)	San Francisco	98		400
	San Mateo	89		
	Santa Clara	54		
	Alameda	31		
Local Reservoirs (SFWD)	Unallocated	-		35
Subtotal		272	335	435
Mokelumne River (EBMUD)	Alameda Contra Costa	190	300	300
Reservoirs (EBMUD)	Alameda Contra Costa	20	0	0
American River (USBR/EBMUD)	Alameda Contra Costa	0	0	134
South Bay Aqueduct (DWR)	Alameda	16[b]	78	78
	Santa Clara	105	89	89
Subtotal		121	167	167
Niles Cone Groundwater (ACWD)	Alameda	27	22[c]	22[d]
Livermore-Amador Valley Groundwater (ACFCWD 7)	Alameda	24	18[c]	18[d]
Del Valle Reservoir (ACWD)	Alameda	0	0	3

TABLE II-4
(Continued)

SURFACE WATER AND GROUNDWATER SUPPLY
SOURCES FOR THE BAY AREA
(mgd)

Source (Wholesaler)	Counties Served	Supplied in 1975-76	Existing Deliverable[a]	Ultimate Available[a]
Delta-Contra Costa Canal (USBR/CCCWD)	Contra Costa	60[b]	125[c]	135
East Contra Costa County	Contra Costa			
Delta		105	NA	NA
Groundwater		5	NA	NA
Subtotal		110		
North Santa Clara County				
Groundwater	Santa Clara	122[e]	86[c]	86[d]
Reservoirs	Santa Clara	21[e]	51[c]	51
Subtotal (SCVWD)		143	137	137
South Santa Clara County				
Groundwater	Santa Clara	57[e]	57[c]	57[d]
Reservoirs	Santa Clara	14[e]	14[c]	14
Subtotal (SSCVWD)		71	71	71
San Felipe Division of CVP (SCVWD)	Santa Clara	0	0	134
San Mateo County				
Existing Reservoirs	San Mateo	5	NA	NA
Potential Reservoirs	San Mateo	0	NA	NA
Groundwater	San Mateo	12	NA	NA
Subtotal		17		

TABLE II-4
(Continued)

SURFACE WATER AND GROUNDWATER SUPPLY
SOURCES FOR THE BAY AREA
(mgd)

Source (Wholesaler)	Counties Served	Supplied in 1975-76	Existing Deliverable[a]	Ultimate Available[e]
Russian River				
Wohler Diversion	Sonoma	21		33
(SCWA)	Marin	8		
Other Diversions	Sonoma	23		NA
Subtotal		52	58	58
Lake Sonoma (USCE)	Sonoma-Marin	0	0	102
Sonoma Valley Groundwater	Sonoma	48	47[c]	47[d]
Existing Marin Co. Reservoirs (MMWD & NMCWD)	Marin	28[e]	18	18
New Marin County Reservoirs (MMWD)	Marin	0	0	11
Marin County Groundwater	Marin	2	NA	NA
Lake Berryessa-Putah South	Solano	190		189[f]
Canal (USBR/SCFCWCD)	Napa	10		11[g]
Subtotal		200	200	200
North Bay Aqueduct	Solano	0		33
(DWR)	Napa	0		22
Subtotal		0	0	55

TABLE II-4
(Continued)

SURFACE WATER AND GROUNDWATER SUPPLY
SOURCES FOR THE BAY AREA
(mgd)

Source (Wholesaler)	Counties Served	Supplied in 1975-76	Existing Deliverable[a]	Ultimate Available[a]
Solano County-Delta	Solano	35	NA	NA
Cache Slough (City of Vallejo)	Solano	13	20	20
Existing Solano Co. Reservoirs (City of Vallejo)	Solano	3	3	3
Solano County Groundwater	Solano	132	132	132
West Sacramento Canal Unit (USBR)	Solano	0	0	120
Existing Napa Co. Reservoirs	Napa	17	17	17
Napa County Groundwater	Napa	9	9	9
Total Existing Sources		1,594	1,843	1,843
Total Planned Future Sources				669
Total All Sources		1,594	1,843	2,512

TABLE II-4
(Continued)

SURFACE WATER AND GROUNDWATER SUPPLY
SOURCES FOR THE BAY AREA
(mgd)

NA denotes not available but assumed equal to 1975 usage for totals

[a]Estimated for previous worst drought on record, generally 1928-1935; subject to revision after 1976-77 drought

[b]1976

[c]To equal safe yield

[d]Natural safe yield without artificial recharge

[e]FY 1974-1975

[f]Prior to North Bay Aqueduct construction

[g]Zero after North Bay Aqueduct constructed

TABLE II-5

STORAGE CAPACITIES AND SAFE YIELDS OF
SOURCES OF WATER SUPPLY IN
THE SAN FRANCISCO WATER DEPARTMENT SYSTEM

Source	Location	Storage Capacity acre-ft	Minimum Safe Yield acre-ft/yr
Local Sources			
Calavaras Res.	Santa Clara Co.	31,550	25,000
San Antonio Res.	Alameda Co.	16,600	4,500
Pilarcitos Lake	San Mateo Co.	1,010	3,400
San Andreas Res.	San Mateo Co.	6,190	
Crystal Springs Res.	San Mateo Co.	22,580	3,200
Sunol Filter Galleries	Alameda Co.	--	3,500
Subtotal		77,930	39,600
Sierra Reservoirs			
Hetch Hetchy Res.	Tuolumne Co.	360,360	
Lake Lloyd	Tuolumne Co.	268,800	450,000
Lake Eleanor	Tuolumne Co.	27,100	
Don Pedro Res.*	Tuolumne Co.	570,000	
Subtotal		1,226,260	450,000
Total System		1,304,190	489,600

*SFWD's share of total storage which is used to supply water to downstream water rights holders (Modesto and Turlock Irrigation Districts)

rights. In past years the Hetch Hetchy Reservoir was used for the SFWD water supply and Lake Lloyd and Lake Eleanor were used to meet downstream water requirements. The estimated minimum safe annual yield for water supply from the SFWD reservoirs is 450,000 acre-feet. In 1975-1976 the SFWD drew 215,000 acre-feet from this source.

The SFWD now sells almost two-thirds of its water to customers outside of the City of San Francisco (see Figures II-2 and II-3). Most of these customers are totally dependent upon the SFWD for water supply. Each of these customers has a standard contract with the SFWD specifying minimum and maximum amounts that can be purchased in any given year. These contracts all expire in 1981 and are subject to renegotiation. Therefore, no analysis of the supply and demand on a city-by-city basis is presented. Due to growth in the suburban counties it may be necessary for the SFWD either to increase their aqueduct capacity or eliminate or reduce allocations to some customers to be able to continue serving those customers who have traditionally relied upon the SFWD for water.

South Bay Subregion

Santa Clara Valley Water District. This district manages the water resources of Santa Clara County north of Morgan Hill. Presently, water needs in this area are met from four sources which include natural groundwater, surface water, the South Bay Aqueduct of the State Water Project, and the San Francisco Water Department's Hetch Hetchy system.

Groundwater has been the traditional or principal water source for most of Santa Clara County. The three groundwater basins in the county are all interconnected and occupy approximately one-fourth of the land area of the county. The estimated total natural yield from these basins, tabulated in Table II-6, can provide 161,700 acre-feet in an average rainfall year. Pumping of these aquifers can safely exceed this amount without depleting the water in storage if natural percolation is augmented with artificial recharge from surface water. The Santa Clara Valley Water District (SCVWD) manages the Santa Clara Valley groundwater basin and operates an extensive network of percolation basins to augment the natural yield.

The surface reservoirs in Santa Clara County are listed in Table II-7. In 1974-1975 approximately two-thirds of the yield from surface reservoirs was used for artificial recharge.

TABLE II-6

ESTIMATED NATURAL GROUNDWATER YIELD IN SANTA CLARA COUNTY

Source	Yield acre-ft/yr
Santa Clara Valley Basin	
West Zone	51,000
Central Zone	27,800
East Zone	18,600
Subtotal	97,400
Coyote Basin	5,500
Llagas Basin	
Morgan Hill-San Martin Area	18,800
Gilroy-Uvas Area	40,000
Subtotal	58,800
Total	161,700

Source: Master Plan Expansion of In-County Water Distribution System, Santa Clara Valley Water District, December, 1975.

Imported surface water, supplied by the SFWD, is now an important component of water supply in the South Bay. Because contracts for this water will be renegotiated in 1981, the ultimate amount of water available from this source is uncertain at this time. Since 1965 the SCVWD has been receiving deliveries from the South Bay Aqueduct. In 1975-1976, 118,700 acre-feet was delivered from this source. Table II-8 presents the schedule of annual entitlements to South Bay Aqueduct water. Excess water above the annual entitlement can be purchased when available, as was done in 1975-1976. The capacity of the aqueduct is 210,000 acre-feet/year, which implies that 22,000 acre-feet/year might be made available by DWR for a future contractor. However, because the Department of Water Resources has made no commitment to provide this water, it was not considered in this study. Presently 35 percent of South Bay Aqueduct water is used to recharge the Santa Clara Valley groundwater basin and 65 percent is treated at the Rinconada or Penitencia treatment

TABLE II-7

SURFACE RESERVOIR YIELD* IN SANTA CLARA COUNTY

Source	Yield acre-ft/yr
Santa Clara Valley Basin	
Almaden-Calero	5,800
Anderson-Coyote	24,300
Guadalupe	2,400
Lexington-Vasona	11,700
Stevens Creek	2,500
Williams-Elsman	13,000
Subtotal	59,700
Coyote Basin	
Anderson-Coyote	5,300
Llagas Basin	
Anderson-Coyote	1,900
Chesbro	3,800
Uvas	4,700
Subtotal	10,400
Total	75,400

*Chesbro and Uvas yields are estimated firm yields; all other reservoir yields are long-term average operational yields.

Source: Master Plan Expansion of In-County Water Distribution System, Santa Clara Valley Water District, December, 1975.

TABLE II-8

SCHEDULE OF ANNUAL ENTITLEMENTS TO
SOUTH BAY AQUEDUCT CONTRACTORS
(acre-ft)

Calendar Year	Alameda County FC & WCD Zone 7	Alameda County Water District	Santa Clara Valley Water District	Total
1974	14,800	19,600	88,000	122,400
1975	16,000	20,500	88,000	124,500
1976	17,200	21,300	88,000	126,500
1977	18,400	22,200	88,000	128,600
1978	19,600	23,100	88,000	130,700
1979	20,800	23,900	88,000	132,700
1980	22,000	24,800	88,000	134,800
1981	23,000	26,000	88,000	137,000
1982	24,000	27,200	88,000	139,200
1983	25,000	28,400	88,000	141,400
1984	26,000	29,600	88,000	143,600
1985	27,000	30,800	88,000	145,800
1986	28,000	32,100	88,000	148,100
1987	29,000	33,300	88,000	150,300
1988	30,000	34,500	88,000	152,500
1989	31,000	35,700	90,000	156,700
1990	32,000	36,900	92,000	160,900
1991	34,000	38,400	94,000	166,400
1992	36,000	39,900	96,000	171,900
1993	38,000	41,400	98,000	177,400
1994	40,000	42,000	100,000	182,000
1995	42,000	42,000	100,000	184,000
1996	44,000	42,000	100,000	186,000
1997	46,000	42,000	100,000	188,000
1998	46,000	42,000	100,000	188,000
1999	46,000	42,000	100,000	188,000
2000	46,000	42,000	100,000	188,000

Source: Master Plan Expansion of In-County Water Distribution System, Santa Clara Valley Water District, December, 1975.

plants and distributed to various local water agencies (see Figure II-3).

Water demand in Santa Clara County is nearing the capacity of existing sources. A number of alternative sources of water supply were evaluated in a 1975 report by the SCVWD. This report recommended construction of the San Felipe Division of the Central Valley Project. This water would be diverted from the Sacramento-San Joaquin Delta and through San Luis Reservoir where the Pacheco tunnel would convey water to Santa Clara, San Benito, Santa Cruz, and Monterey counties. Out of the total annual delivery of 217,000 acre-feet to these counties, approximately 150,000 acre-feet has been allocated to Santa Clara County under a contract between the United States Bureau of Reclamation and the SCVWD. The project has been delayed by lawsuits recently, but now appears to be proceeding. A bond issue to finance the local share of construction was passed in Santa Clara County in June 1977.

East Bay Subregion

Alameda County Water District. There are three major sources of water available to the Alameda County Water District (ACWD). Groundwater from the Niles Cone has traditionally been the major source of supply. The safe annual yield of that portion of the groundwater basin currently being used is 10,000 acre-feet. Extractions have exceeded this amount, however, presenting a salt water intrusion problem in the groundwater aquifer. In 1975 the ACWD pumped 30,200 acre-feet. It is planned to renovate this aquifer prior to 1980 by inducing a salt water intrusion barrier with artificial recharge of imported surface water and pumping out the contaminated saline waters. When this is done, the groundwater safe yield would be increased to 25,000 acre-feet per year. The ACWD has a contract with the SFWD for water supply through the year 1984. Annual deliveries after 1982 are fixed at a minimum of 6,000 acre-feet and a maximum of 18,000 acre-feet. In 1976 the ACWD withdrew approximately 11,300 acre-feet from this source. They anticipate using a constant annual rate of 10,000 acre-feet after 1984. The ACWD has a contract with the California Department of Water Resources for an annual supply of up to 42,000 acre-feet. Use of water from this source began in 1976 following construction of a treatment plant with an annual treatment rate of 9,000 acre-feet. Availability of this source of water supply permitted comparable reductions in the use of

groundwater in 1976 so that pumping rates became closer to the safe yield of the groundwater basin.

Alameda County Flood Control and Water Conservation District-Zone 7. The District obtains groundwater from the Livermore Valley and imported surface water from the South Bay Aqueduct. The District supplies raw water to the Valley Community Services District and the City of Pleasanton and treated water to California Water Service, the City of Livermore, and the V. A. Hospital. The District shares water storage equally in Del Valle Reservoir with the Alameda County Water District. The District is responsible for managing the operation of the Livermore Valley groundwater basin and in 1975 they recharged approximately 7,800 acre-feet. In 1975 approximately 14,000 acre-feet of water was obtained from the South Bay Aqueduct. This represented 65 percent of the total water that Zone 7 supplied. As shown in Table II-8, their present contract with the Department of Water Resources entitles them to up to 46,000 acre-feet of water annually from the South Bay Aqueduct. The unused portion, or 31,000 acre-feet annually, is considered a future water supply.

East Bay Municipal Utility District. The principal water source for the East Bay Municipal Utility District (EBMUD) is the Mokelumne River. EBMUD has rights to divert 325 mgd, or 365,000 acre-feet annually, from the river. Deliveries from this source began in 1929, and in 1975 EBMUD obtained approximately 58 percent of maximum diversion. EBMUD has two reservoirs on the Mokelumne River. Pardee Reservoir, completed in 1929, holds 210,000 acre-feet when full and Camanche Reservoir, completed in 1964 and located downstream of Pardee, has a maximum capacity of 431,000 acre-feet. Presently, Pardee is used for water supply via the Mokelumne Aqueduct and Camanche is used to meet downstream flow requirements and for flood control. The amount of water that must be released to satisfy downstream water rights has been increasing recently because of increased seepage losses from the river. Increases in seepage losses are attributed to the overpumping of aquifers for irrigation in the Lodi area by various farmers and irrigation districts that has caused a decline in the water table. If this situation persists, EBMUD expects that the firm yield from the Mokelumne may eventually drop to as low as 260 mgd. The Folsom South Canal, if extended to southern San Joaquin County, would help to alleviate this problem. The 1976-1977 drought may change the Mokelumne firm yield reported in Table II-2 because the actual yield was considerably less in 1976-1977.

EBMUD signed a contract in 1970 with the United States Bureau of Reclamation to purchase up to 150,000 acre-feet annually of American River water from the Auburn-Folsom South Project. Water will be delivered through an existing portion of the Folsom South Canal to a point where EBMUD would have to construct an aqueduct to the East Bay. Until the current drought, EBMUD did not intend to begin importing water from the American River until the late 1980's.

Contra Costa County Water District. The Contra Costa County Water District (CCCWD) operates the Contra Costa Canal. This canal is a part of the United States Bureau of Reclamation's Central Valley Project. During periods of low natural flow, water is released from Lake Shasta to flow down the Sacramento River and across the Delta to the canal intake at Rock Slough. The CCCWD is provided with this water under a contract with the United States Bureau of Reclamation. This contract requires a minimum purchase of 86,000 acre-feet annually. After 1980, minimum annual purchases would increase gradually up to an additional 63,000 acre-feet. Total supply obtained from the canal in 1986 is expected to be approximately 153,000 acre-feet, or an average of 130 mgd.

The capacity of the Contra Costa Canal along the length of the canal decreases from 210 mgd in the first section after the water is pumped from Rock Slough to 20 mgd at the end of the canal. Storage of 2,000 acre-feet of canal water is provided at Contra Loma Reservoir in Antioch.

Marin-Sonoma Subregion

Sonoma County Water Agency. The Sonoma County Water Agency (SCWA) draws nearly all of its water from the Russian River. The principal diversion has been the Wohler intakes located upstream of Forrestville. This water has been transported to the cities of Santa Rosa, Sonoma, Rohnert Park, Cotati, and Petaluma and to the North Marin Municipal Water District via a system of aqueducts. To augment capacity for supplying the City of Petaluma and northern Marin, the Russian River-Cotati Intertie pipeline was constructed in 1977. The project diverts water from the Russian River via the Mirabel intakes at Forrestville.

Year-round diversion from the Russian River is possible because the flow is partially regulated by Lake Mendocino,

which is located upstream of Ukiah. Lake Mendocino is a flood control and water supply project having a gross storage of 122,500 acre-feet and an annual water supply yield of 70,000 acre-feet. A portion of this available water comes from the Eel River and Lake Pillsbury through the Potter Valley tunnel. Annual diversions from the Eel River have averaged 184,000 acre-feet. This represents approximately 40 percent of the total flow in the Eel River, but most of the diversion occurs in the winter.

The United States Army Corps of Engineers has begun construction of Warm Springs Dam (Lake Sonoma) on Dry Creek, a tributary of the Russian River. This project is currently suspended due to litigation concerning the adequacy of the Environmental Impact Statement. As presently planned, Lake Sonoma would have a gross storage of 381,000 acre-feet. The Corps estimates that the increased annual yield to the Russian River system would be 115,000 acre-feet. This water would presumably be available to the SCWA and others for meeting water supply needs.

The SCWA draws less than two percent of its water from wells in the Santa Rosa area. However, many individuals and several cities in the rural and semi-rural areas of the county are dependent upon wells for their water supply. The estimated total annual safe yield of the groundwater basins in this area is approximately 53,000 acre-feet, distributed as follows:

Alexander Valley	3,000 acre-feet/year
Santa Rosa/Healdsburg Valley	30,000 acre-feet/year
Petaluma Valley (partially in Marin County)	10,000 acre-feet/year
Sonoma Valley	10,000 acre-feet/year

Total use from this source in 1970 was estimated at 48,100 acre-feet. An increase in groundwater pumping rate of 20,000 acre-feet per year would not reduce groundwater resources due to the recharge capability of the aquifers [Reference 2].

Marin Municipal Water District. The Marin Municipal Water District (MMWD) obtains approximately 93 percent of its water from local runoff in Marin County. The remainder is purchased from the Sonoma County Water Agency and transported to the MMWD via the North Marin Aqueduct and (by separate agreement) the North Marin County Water District's distribution system. This source is available only in off-peak periods.

The MMWD operates four reservoirs in Marin County. In FY 1975-1976, each reservoir supplied the following relative amounts of water: Nicasio, 56 percent; Kent, 24 percent; Bon Tempe, 19 percent; and Alpine, one percent.

The need for future water supply has been evaluated by MMWD [Reference 3]. Fourteen alternative projects were considered, including increased importation from Sonoma County, extension of the North Bay Aqueduct into Marin County, and twelve local projects. Of these alternatives, four appeared to be viable: a dam on San Antonio Creek, a dam on Walker Creek, a diversion on Lower Lagunitas Creek, and raising the dam at Kent Lake. In addition, enlargement of the existing Soulajule Dam is under construction and should be in operation by 1980. This project will provide a safe annual yield of 3,700 acre-feet. Of the future projects studied, the San Antonio Dam is the most feasible now, but does present political and environmental problems. The reservoir would be partially in Marin County and partially in Sonoma County and would flood a productive dairy farm area. This project would provide up to an additional 9,000 acre-feet of safe yield annually. Each of these two safe yields is an estimate based upon the 1976-1977 drought and an assumed return to a normal year in the winter of 1977-1978. Previous estimates using the 1928-1935 dry period resulted in estimates of safe yield which were about one-third higher than these revised estimates. As a consequence, the MMWD now rates their existing reservoirs and the North Marin Intertie at 23,000 acre-feet annual safe yield instead of the previous estimate of 30,000 acre-feet. [Reference 4].

North Marin County Water District. The North Marin County Water District (NMCWD) has two sources of supply. Stafford Lake on the upper reaches of Novato Creek has a storage capacity of 4,450 acre-feet and a net safe annual yield of 2,000 acre-feet. Since 1962 the NMCWD has been obtaining water from the Russian River through an agreement with the Sonoma County Water Agency. By 1967 this source provided about half the District's water, and in 1975-1976 approximately 78 percent of the water supply was obtained from this source. Their present contract with Sonoma County Water Agency provides for up to 10,000 acre-feet of water supply annually from the Russian River. In 1975-1976, approximately 4,000 acre-feet of this entitlement had not been used and can be considered a source of future water supply.

Napa-Solano Subregion

Solano County Flood Control and Water Conservation District. The principal source of surface water in the Napa-Solano subregion is Lake Berryessa, which was built by the United States Bureau of Reclamation (USBR). The USBR contracts with the Solano County Flood Control and Water Conservation District (SCFCWCD) for use of this water. Consequently, the SCFCWCD is the principal water wholesaler in Solano County. Water from this source is conveyed in the Putah South Canal, which is operated by the Solano Irrigation District, the major purveyor of agricultural water in Solano County. In 1975-1976 the SCFCWCD supplied the amount of water shown in Table II-9. Also shown are the contract maximum amounts. For the City of Benecia and the Napa County Flood Control and Water Conservation District, these contracts are for an interim period until the North Bay Aqueduct is constructed. After this project is completed, these two agencies would receive water directly from the North Bay Aqueduct under contract with the State.

TABLE II-9

WATER SUPPLIED BY THE SOLANO FLOOD CONTROL AND WATER CONSERVATION DISTRICT

Agency	Water Year 1975-76 acre-ft	Contract Maximum acre-ft/yr
City of Fairfield	5,075	9,200
Suisun City	478	1,600
City of Benecia	8,422	12,000*
City of Vallejo	3,258	14,750
City of Vacaville	1,661	5,600
U. C. Davis	3,626	--
California Medical Facility	149	--
Napa County Flood Control and Water Conservation District	5,665	12,500*
Solano Irrigation District	175,100	141,000
Main Prairie Water District	33,000	--

*Interim contract in force until the North Bay Aqueduct is completed.
Source: Solano County Flood Control and Water Conservation District.

Solano Irrigation District. The Solano Irrigation District (SID) supplies water for irrigated agriculture on approximately 51,000 acres in Solano County. A report for the District [Reference 5] indicates that the current available annual water supply of 170,000 acre-feet consists of 141,000 acre-feet from Lake Berryessa, 15,000 acre-feet pumped by the SID, 10,000 acre-feet pumped by farmers, and 4,000 acre-feet recovered from excess irrigation. In the future the SID expects to increase their pumping rate and use reclaimed water (12,000 acre-feet annually) from the City of Fairfield. Their potential annual water supply will total 198,000 acre-feet. During most years they are able to get more water from Lake Berryessa; for example, as shown in Table II-9, they purchased 34,000 acre-feet of additional water in 1975-1976 from the Solano County Flood Control and Water Conservation District.

City of Vallejo. In addition to the water obtained from the Solano County Flood Control and Water Conservation District, the City of Napa obtains water from three small lakes--Fry, Madigan, and Curry--and from the Delta through their own project--Cache Slough. In 1975-1976 the lake system provided 3,000 acre-feet, which was close to the safe yield of approximately 3,400 acre-feet. In 1975-1976 Cache Slough provided approximately 14,800 acre-feet, which was about two-thirds of their permitted entitlement of 23,000 acre-feet.

City of Fairfield. The City of Fairfield can obtain water from two sources. All of their water now comes from the Solano County Flood Control and Water Conservation District. In addition to the 9,200 acre-feet of water annually they are entitled to from this district, they have rights to another 9,000 acre-feet annually from the Solano Irrigation District. The water they obtain from the Solano Irrigation District is in exchange for reclaimed wastewater that the city will provide the District for agricultural irrigation. In 1975 the City of Fairfield used approximately 7,800 acre-feet of water from Lake Berryessa. The City of Fairfield also has a contract with the City of Vallejo to take up to 3,400 acre-feet of water annually from Cache Slough. This source has not been used recently because of inferior water quality; this contract expires in 1982.

Napa County Flood Control and Water Conservation District. The Napa County Flood Control and Water Conservation District (NCFCWCD) is the water wholesaler in Napa County. They have a contract with the State for North Bay Aqueduct water up to

25,000 acre-feet annually. Of this amount, the District has allocated 12,500 acre-feet annually to the American Canyon County Water District; they have not allocated the remaining 7,100 acre-feet. At the present time, and until the North Bay Aqueduct is completed, the NCFCWCD has a contract with the Solano County Water Conservation District for up to 12,500 acre-feet of water annually, which is excess water from Lake Berryessa transported to Napa County in the Putah South Canal.

City of Napa. The City of Napa has three sources of water. In 1975-1976, Lake Hennessey provided 5,100 acre-feet, or 40 percent of the total water used; Lake Milliken provided 700 acre-feet, or six percent; and the North Bay Aqueduct (via the Putah South Canal) provided 6,900 acre-feet, or 54 percent.

The safe annual yield of Lake Hennessey is 8,800 acre-feet; but because this source is not treated, it can only be used when the water quality meets public health standards. The safe annual yield of Lake Milliken is 1,200 acre-feet. The contract for North Bay Aqueduct water is with the Napa County Flood Control and Water Conservation District and the maximum annual entitlement for the City of Napa is 12,500 acre-feet.

American Canyon County Water District. The District has been using North Bay Aqueduct water for the last few years. In 1977 the District expects to complete their own water treatment plant to replace a service that had been provided by the City of Napa. In 1975 they used 867 acre-feet of water from the North Bay Aqueduct. Their contract with the Napa County Flood Control and Water Conservation District provides for a gradually increasing annual entitlement to water of up to 5,400 acre-feet in year 2000; thereafter the annual entitlement will remain constant.

Summary of Planned Future Sources of Water and Costs of Source Development

A number of additional sources of water supply are being planned for the Bay Area. A summary of these projects is presented in Table II-10. (Location of the portions of these projects that are within the Bay Area are shown in Figure II-1.) The quantities of water available are contractual or estimated maximum amounts of water that can be obtained based upon the present estimate of safe yield of the reservoir system. Costs for developing the sources were taken from the sources listed in the footnotes for Table II-10. As evident from these notes, the development costs are

TABLE II-10

AVAILABILITY AND COSTS OF
MAJOR NEW SOURCES OF WATER SUPPLY

Project	Maximum Amount of Water Available		Development Costs[a]		Unit Costs[b]	
	acre-ft	mgd	Capital 10^6 $	O & M 10^6 $/yr	$/acre-ft	¢/kgal
Hetch Hetchy Expansion[c]	112,600	100	60.0	0.675	48.20	14.80
American River[d]	150,000	134	149.0	5.839	96.82	29.72
San Felipe[e]	150,000	134	57.0	8.318	78.25	24.00
Warm Springs Dam[f]	115,000	102	61.8	0.063	32.70	10.38
North Bay Aqueduct[g]	62,800	55	31.0	0.940	68.84	21.13
West Sacramento Valley Canal[h]	135,000	120	425.0	NA	NA	NA

NA denotes not available

[a]Development costs include cost of purchasing water (if any), or reservoir construction and conveyance costs to Bay Area. Costs exclude treatment and distribution; all costs in 1977 dollars, ENR Index = 3100.

[b]Unit costs based upon delivering maximum amount of water.

[c]Source: Draft Master Water Plan for San Mateo County, by Leeds Hill and Jewitt, March 1977

[d]Source: East Bay Municipal Utility District letter to J. B. Gilbert & Associates, July 18, 1977. Operation and maintenance costs and unit costs include costs of purchasing water from U. S. Bureau of Reclamation, which is $16/acre-ft and conveyance costs. Costs exclude treatment.

[e]Source: Development Costs taken from "The Water Utility Enterprise, Final--March 1977" by the Santa Clara Valley Water District and represent the cost to Santa Clara County of water purchase at the maximum rate and intra-County conveyance and treatment. Amount of water available and costs of water purchased from the Bureau taken from "Master Plan Expansion on In-County Water Distribution System" by the Santa Clara Valley Water District, December 1975. Water purchase costs are $61/acre-ft for M/I water and $17.50/acre-ft for agricultural water.

TABLE II-10
(Continued)

AVAILABILITY AND COSTS OF
MAJOR NEW SOURCES OF WATER SUPPLY

[f]Source: Sonoma County Water Agency; costs updated using ENR index, and represent costs of multipurpose project associated with water supply only. Costs include reservoir construction and exclude conveyance and treatment.

[g]Source: California Department of Water Resources Bulletin 132-76. Quantities shown as available are for year 2035; in year 2000, 52,200 acre-ft (47 mgd) will be available to Napa and Solano counties. Unit costs are average for water purchased and delivered to the two counties.

[h]Source: Personal communication, Andrew W. Ferrar, United States Bureau of Reclamation, July 12, 1977. Quantity of water available is Solano County's portion of supply. Capital cost is for total project, not Solano County's share.

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only relatively comparable because they include different cost items. They do, however, reflect the costs that will be incurred by the water agency responsible for developing the source. Expansion of the Hetch Hetchy system to add 100 mgd of additional capacity would involve building the fourth barrel of the aqueduct. This would enable the San Francisco Water Department to import 400 mgd from their Tuolumne system. This amount is their estimate of the safe yield of the reservoirs on the Tuolumne River. Costs do not include additional water treatment. Allocation of this water within their existing service area has not been made, but it is assumed in this study that it would be allocated to San Francisco, San Mateo, Santa Clara, and Alameda counties in proportion to the amount of water they currently use. On this basis, approximately 36 mgd would be available to San Francisco County, 33 mgd to San Mateo County, 20 mgd to Santa Clara County, and 11 mgd to Alameda County. A decision on how to allocate this water, if this project is built, would probably be made by the San Francisco Water Department in the early 1980's when their present contracts with the distribution agencies expire.

The East Bay Municipal Utility District has contracted with the United States Bureau of Reclamation for up to 150,000 acre-feet

annually from the American River. Their current estimate of importing this water to Walnut Creek is $97.00 per acre-foot. This includes the cost of the aqueducts, but not any additional treatment or distribution system expansion. Although the East Bay Municipal Utility District began paying on this contract with the Bureau in 1974, they had not planned on taking deliveries of water until the late 1980's. Because of the drought, however, the District began delivering water under this contract on September 1, 1977 temporarily through their Mokelumne Aqueduct. This was accomplished by diverting water released from the United States Bureau of Reclamation's Central Valley Project through the Sacramento-San Joaquin Delta into a temporary pumping plant located where the Mokelumne Aqueduct crosses the Middle River.

The San Felipe Division of the Central Valley Project has been designed to supply water to Santa Clara, San Benito, Santa Cruz, and Monterey counties. Table II-10 presents the water allocation to Santa Clara County from this project and the capital costs to Santa Clara County for expanding their intra-county conveyance system and their water treatment plants. Construction has began on this project and will extend to 1983 when water deliveries from the San Felipe Division are expected to begin. Capital costs for the project have been escalated by the Santa Clara Valley Water District to the year of construction. The unit cost of purchasing this water from the United States Bureau of Reclamation is $61.00 per acre-foot for municipal water and $17.50 per acre-foot for agricultural water. Operation and maintenance costs listed in Table II-10 include incremental costs of purchasing and delivering San Felipe water. Water purchase costs were computed using an assumed aggregate price of $52.00 per acre-foot. Unit costs include amortized capital costs (6-3/8 percent for 40 years) and operation and maintenance costs.

The Warm Springs Dam Project on Dry Creek, a tributary of the Russian River, is being built by the United States Corps of Engineers; conveyance of water for municipal and industrial needs in Sonoma and Marin counties would be built by the Sonoma County Water Agency. Costs shown in Table II-10 are the local share of the reservoir cost. Costs do not include conveyance to water distribution agencies in Sonoma and Marin counties or subsequent water treatment required. Conveyance until 1985 or 1990 will be accomplished by the existing aqueducts. After that time, new aqueducts might be required.

The North Bay Aqueduct will deliver water from the Sacramento River to Solano and Napa counties. Contract maximums, beginning

in the early 1980's when the State Department of Water Resources anticipates the project will be built, increase every year to 62,300 acre-feet in year 2035. The Department's charge for the water will average $68.84 per acre-foot, but will be higher for Napa County due to the greater conveyance distance. To these costs must be added any local costs of treatment and distribution.

The West Sacramento Valley Canal Unit could deliver 135,000 acre-feet annually to Solano County, as well as additional water to Lake and Yolo counties. Estimated capital costs for the entire project are approximately $425 million, and include construction of Sites Reservoir for off-line storage of excess flows in the Sacramento River, extension of the Tehema-Colusa Canal to Solano County, and construction of Oat Reservoir as a part of the terminal facilities. Unit charges to Solano County and intra-county conveyance and treatment costs have not been estimated. This project was last studied in the 1960's, but the United States Bureau of Reclamation plans to re-study the project feasibility in the near future. Consequently, it can only be considered a long-range source of water supply for Solano County.

These six projects together could supply the Bay Area with 645 mgd of water. Although other projects may be proposed in the future, it is considered unlikely that they would be constructed before the aforementioned projects or before the end of the planning horizon for this study, i.e., the year 2000. Other major projects are likely to be more expensive than these six projects per unit amount of water delivered. Also, many years are required for planning, water rights and water contract negotiations, and design and construction. Moreover, water resources in California are extensively developed and there may be no other major sources of water available to the Bay Area.

CHAPTER III

WATER CONSERVATION

Conservation of water can be practiced by consumers usually without impairing their derived benefits from the water. Such conservation can result in small, but significant, reductions in the total amount of water needed and used. Conservation, coupled with wastewater reclamation and reuse, reduces the requirement for conventional potable water supplies.

In the context of this study, the nature, extent, and implementation of water conservation measures are based on practices which can reasonably be achieved without major sacrifice of either convenience or economic factors. That is, water conservation has been approached, not from a drought-inspired position, but from a basis of what can be reasonably achieved from an informed and conscious public. Water conservation achieved during the current drought, and the concomitant reduction in demand on water supplies, has provided however an invaluable measure of the extent to which water users will respond in an emergency situation.

CHARACTERISTICS OF BAY AREA WATER USE

To delineate potentially effective water conservation measures and establish meaningful water conservation models, it is necessary to identify the characteristics of water use in the Bay Area. These characteristics are presented in detail in Chapter IV, but are summarized here to set forth the rationale for the water conservation measures developed in this chapter.

An analysis of current (1975) residential, commercial, industrial, public authority, unaccounted-for, and agricultural water use in the nine-county Bay Area indicates that the demand is distributed as shown in Table III-1.

Of the water supplied for residential purposes, 69 percent is used inside the residence and 31 percent is used outside, principally for landscape irrigation. Water within the home is used [Reference 6] as follows: toilet flushing, 45 percent;

bathing, 30 percent; laundry and dish washing, 20 percent; and drinking and culinary, five percent. Of the total residential water use, one-half occurs in the bathroom and about one-third occurs outside, for a combined 83 percent of all residential consumption. An effective water conservation program, therefore, must focus on these two components of residential water use.

TABLE III-1

WATER USE IN THE BAY AREA
(1975)

Category	Water Use mgd	Percentage of Total
Municipally-supplied		
Residential		
Inside	346.0	22.0
Outside	155.2	9.8
Subtotal	501.2	31.8
Commercial-industrial	311.8	19.8
Public authority	61.2	3.8
Unaccounted-for	60.2	3.8
Subtotal	934.4	59.2
Agriculture	643.9	40.8
Total	1,578.3	100.0

RESIDENTIAL WATER CONSERVATION MEASURES

The following section discusses six broad areas presenting water conservation opportunities in residential water use. Most require the cooperation of the consumer. All require a commitment by the utility.

Consumer Education

Of the available ways of achieving water conservation, changing habits through consumer education or conditioning is perhaps the most elusive and hardest measure for which to predict success. It has been demonstrated that in a crisis, a well presented public information program which defines the problem clearly and sets forth explicit solutions and achievement goals will yield the desired results. The City of New York achieved a 12 percent reduction in annual water use during the drought of 1965 [Reference 7]. The Pinellas County Water Department in Florida (400,000 service population), faced with a water shortage and potential salt water intrusion, achieved a 30 percent cutback in water usage in 1973 [Reference 7]. In the Bay Area in 1976, the Marin Municipal Water District achieved a 27 percent reduction in annual demand in reaction to the first year of the current drought in northern California. As the drought continued, most of the Bay Area water distribution agencies implemented information programs which have led to achievement of significant reduction in water use. In the second year of drought, the Marin Municipal Water District, having the worst water shortage in the Bay Area, implemented in January 1977 an information and rationing program aimed at achieving a reduction in use of 57 percent; in July the program had achieved an extraordinary savings of 63 percent as compared to a normal year.

An effective consumer education program, however, must be continuously promoted. It cannot, nor should it properly, rely on a foundation predicated on crisis or even the threat of a future crisis. Crisis programs cannot sustain continued conservation at even reasonable levels according to the experience of New York, where water use approached pre-drought levels within one year after the rationing effort.

When reviewing recent events, most Bay Area water agencies concur, at least as far as suburban residential use is concerned, that somewhere between five and 15 percent of residential water demand is simply wasteful use associated with flushing toilets to dispose of a facial tissue; running water incessantly while washing; brushing teeth, shaving, shampooing hair, or washing cars; and unnecessary over-application of irrigation water.

Because many of these wasteful practices are due to human behavioral habits, which are difficult to change once established, the greatest long-term results in eliminating wasteful habits can be achieved most probably by educating the young. In this regard,

the East Bay Municipal Utility District has pioneered and excelled in the preparation and distribution of many pamphlets, brochures, and other materials all now widely available from which to formulate a consumer education program. Modes of communication are numerous and varied and include the following: bill inserts; direct mail; community service spots on radio and television; paid advertisements; "special interest" articles for newspapers and magazines; posters; exhibits (fairs, shopping centers, etc.); poster coloring, save-water ideas, and slogan contests; speakers bureau; lectures; community forums or conferences; teacher seminars; classroom presentations; facility tours; slide and movie shows; consumer groups; service groups; other volunteer organizations; and central distribution of materials.

Retrofit Programs

There are a large number of devices available for reducing water use in the home that can be retrofit or applied to existing plumbing fixtures. A number of utilities have implemented retrofit programs which are usually coupled with distribution of water conservation information. Most water distribution agencies have assembled kits consisting of:

1. two or more one-quart plastic toilet tank displacement bottles;

2. a shower flow-control insert which reduces maximum shower flow rates;

3. two dye tablets with instructions for conducting a toilet-tank leak test; and

4. instructions for installation, follow-up toilet leak trouble-shooting and repair, and tips and information on water conservation in general.

The Washington Suburban Sanitary Commission, prompted by inadequate sewage treatment and disposal facilities, led in the development of retrofit kits and the conduct of numerous field trials [Reference 8]. The test program involved placement of approximately 4,800 assorted inserts and devices in some 2,400 dwellings in 1971 and 1972. Although the Commission reported infiltration and other factors masked any measurable savings at sewage flow monitoring points, they reported favorable metered

water consumption reductions. The test program led the Commission, in 1973, to undertake a massive door-to-door retrofit kit distribution program for the 315,000 dwellings comprising its service area [Reference 9]. The project involved staged delivery by volunteers and summer help of over 900,000 plastic quart bottles, 600,000 dye tablets, and one-half million information pamphlets. Reported cost of the program was 16¢ per capita, or about 60¢ per household (shower inserts were not included). A follow-up questionnaire mailed to 219,000 customer accounts elicited a 2.8 percent customer response (6,240 returns), which was considered statistically significant. Extrapolated to the entire service area, questionnaire results indicated the following: 33 percent received kit; 23 percent used dye tablets; four percent found leaks; four percent repaired leaks; 30 percent installed bottles; and 29 percent though kit a helpful item.

It was reported [Reference 10] that wintertime water consumption had dropped 4.4 percent following kit distribution. In mid-1974 the Commission launched a program, using bill inserts, making plastic flow-control inserts (Noland type) available by mail to customers upon request. In mid-1975, the Commission reported 300,000 of the 400,000 inserts purchased for the program had been distributed.

In April 1975, facing problems of water supply, the Marin Municipal Water District imported the retrofit-kit approach to California, adding some innovations of their own. The District tried a pilot program first with 21 homes and then expanded it to a sample of 5,000 homes. The kits contained two plastic quart displacement bottles, a flow-restrictor plastic shower-head insert, two dye tablets, and instructions and conservation tips. Water savings resulting from this program could not be clearly established in the winter of 1975-1976 because the District at that time was in the process of implementing a 25 percent-reduction mandatory rationing program. The District subsequently expanded the program and made kits available free to all of its customers at central distribution points and reports high consumer participation. The California Department of Water Resources is currently analyzing the results of an extensive survey made in the area last year.

Early in 1976, eight cities and water distribution agencies in northern Marin County and Sonoma County, threatened with a temporary shortage due to much below normal and late winter runoff to the Russian River, implemented retrofit programs involving distribution of free kits to over 60,000 homes. Kits

containing two bottles, one shower insert, two dye tablets, and instruction and conservation tips; cost of each kit was less than $1.00. Different agencies used different distribution techniques; one went door-to-door using volunteers, and several others used central distribution centers. North Marin County District, for example, utilized a bill-insert inquiry. Kits were assembled by volunteers (bottle tops were cut off to assure circulation of water and weighted with pea gravel) and delivered to the door of responding consumers. Fifty-eight percent of the District's customers responded to the mailer and an additional 24 percent responded when the offer was repeated in early 1977. The District estimates from this that 82 percent of its customers have received kits. In the spring of 1977, a questionnaire was mailed to all customers and 8,900, or 72 percent, of the District's customers responded; 3,000 of the responses were selected at random for analysis. Taking into account the level of penetration and extrapolating results to the whole service area, the District reports the following:

1. Sixty percent of its customers installed bottles and 23 percent of these used one bottle per toilet, 65 percent used two, and 12 percent used three or four per toilet.

2. Five percent of those installing bottles reported unsatisfactory performance.

3. Forty-three percent of the District's customers performed the toilet-leak tests.

4. Thirty percent of the District's customers installed shower inserts; of those, 72 percent installed one insert, 27 percent installed two inserts, and one percent installed three inserts.

Because of the possibility of biased results due to the impact of drought conditions, the District has made no attempt to measure results.

A paper [Reference 11] describing the overall North Marin-Sonoma program predicted overall water savings of 3.5 percent based on an assumed consumer participation of 65 percent and further indicated participating homeowners could expect to save about $4.00 annually on their energy bill.

Programs for New Construction

Extension of water conservation to devices and designs used in new residential construction has been pioneered in the East by the Washington Suburban Sanitary Commission and Fairfax County Water Authority, Virginia, who together provide water to a population in excess of 1.5 million people. In the West, Goleta County Water District in early 1974 adopted an ordinance specifying certain approved devices for residential construction. A building moratorium has precluded any significant installation of devices, however, since there is virtually no construction in that District.

In 1973, the North Marin County Water District developed a water saving plan with a Novato area developer's planned design for 174 townhouse units that involved installation of low-flush (3.5 gal/flush) toilets, shower flow restrictors (3 gpm), aerators on sinks, hot-water pipe insulation and shortened runs, special attention to soil preparation under turf area, and carefully-designed, low-application rate sprinkler systems suitable for the project's clayey soils and controlled by tensiometers. The project was fully landscaped and occupied by late 1976 only a few months before the second year of drought brought the need for rationing to the District. The District calcualtes overall water savings for the project at 33 percent and reports [Reference 12] cost per unit to the developer was $176. Subsequently the District followed up with a voluntary program in which most area developers participated. The plan was made mandatory by District regulation in September 1976.

By mid-1977, the District reports that 1,417 units had participated in the program: 408 were single-family detached units; 833 were single-family attached units; 60 were duplex units; and 116 were apartment units. These were joined by some miscellaneous commercial and public authority connections.

In February and May of 1976, the City of Morro Bay (population 8,500 to 18,00, depending on season) and the City of Ventura (population 73,000) adopted very similar ordinances that require all new construction or replacement plumbing work requiring a permit to utilize low-flush toilets (3.5 gal/flush or less), shower flow heads or restrictors (3.5 gpm maximum), lavatory and kitchen faucet flow controls or aerators (3.5 gpm maximum), and low-flush urinals (3 gpm). Ventura, in addition, required pressure-reducing valves wherever service pressure exceeds 60 psi.

Both cities report relatively good reception for the programs. Morro Bay as of mid-1977 had 251 dwelling units constructed or permi-ted under the program and Ventura reports approximately 1,230 units. Both cities use the building permit process to insure compliance. No measurements of resulting water savings have been undertaken by the two cities.

With the advent of the drought a number of agencies have implemented water saving programs for new construction, including San Luis Obispo County (April 1977) and Santa Barbara County (May 1977).

Metering

It is a widely accepted fact that metering will reduce urban water use. Reductions are especially significant in suburban areas where outside irrigation demand is substantial. A study [Reference 13] for the State Water Resources Control Board concluded that demand in metered Central Valley cities in California averaged about 30 percent lower than unmetered cities in the same area. Studies [Reference 14] for the Federal Housing Administration concluded that metering single-family residential use would reduce demand about 36 percent.

Bay Area water distribution agencies have long had a tradition of metering; consequently, few areas are not metered. Probably the most notable exception is the City of Rohnert Park, which has only recently grown to a population of 14,000.

The cost of metering a typical single-family service in a new development (assuming installation in ground) is currently estimated at $105. Operation, maintenance, reading, and amortization expense can be expected to run about $11 annually.

Pricing

There are five basic forms of retail rate structure employed by water utilities:

1. Flat Rates--used in nonmetered areas, consisting of a constant charge per unit of time irrespective of volume used.

2. Declining Commodity Rates--most common; commodity rate varies inversely with water usage.

3. Uniform Commodity Rates--finding popular acceptance; commodity rate is uniform for all water usage.

4. Seasonal or Peak Demand Rates--gaining interest but currently very few applications; increased summer usage priced higher than base winter usage.

5. Inclining Commodity Rates--normally limited to drought applications; commodity rate varies directly with increasing usage.

In addition, most utilities collect a fixed charge per billing period that is normally not a function of water use but is intended to recover metering and certain administrative costs. Sometimes this fixed charge is set high enough to recover some of the funds needed to meet fixed expense. Increasingly, utilities are including a life-line rate on their rate structure that can be though of as a mini-inclining rate step.

Many variations and combinations of these basic rate forms exist depending on metering practice in the area, classes of use, and conditions unique to a given locality including the land use, growth, and social subsidy policies. All of the forms noted except the first require metering.

Of the various rate forms, declining rates have traditionally been the most popular with water utilities. Those stem from cost-of-service philosophy which reflects the economy-of-scale advantages related to serving the larger customer and which ignores limits on the availability of supply. Neither declining rates nor uniform commodity rates serve to discourage over application of irrigation water, which is estimated to be 20 percent of total applied irrigation water [Reference 15]. The literature now contains a number of studies [References 16, 17, 18] which conclude that residential irrigation demand can be sensitive price and follow the laws of supply and demand.

An approach being studied by several California utilities and already implemented by a few eastern utilities is application of a seasonal rate or peak demand rate. In the case of Fairfax County Water Authority, a base rate of 45¢/100 cu ft applies for all water use in a given billing period. Use in excess of 130 percent of each customer's wintertime use (during any quarterly billing period for which closing meter readings fall between February 1 and April 1) is priced three and one-third times higher, or at $1.50/100 cu ft.

In 1976, a similar peak demand pricing structure was recommended in a report [Reference 19] prepared for the Marin Municipal Water District. In this instance a 58¢/100 cu ft rate was suggested for water used during a given billing period up to 125 percent of average winter month use (basically November through April) and 87¢/100 cu ft (a 50 percent surcharge) was suggested for all use in excess of this level. To implement the proposed program the report recommended that average winter-month use or base-level use be defined for each customer class determined as follows: single-family residential; duplex; multiple family (3 and 4 units); multiple family (5 to 9 units); and multiple family (10 or more units). Institutional, commercial, and industrial users were not included, as uniform commodity rates were suggested for these classes of use. Any user exceeding 125 percent of base-level use established for his class would pay the surcharge rate. It was predicted, based on empirical data and theoretical calculations, that implementation of the rate proposal would yield a six percent increase in revenue together with a reduction in water consumption due to price elasticity of 11 or 12 percent. District officials report implementation of the rate policy is planned but has been temporarily preempted by the severe drought and inclining penalty rates the District currently has in effect.

Many Bay Area water distribution agencies purchase their water in whole or in part from another utility or governmental agency. In these cases, wholesale rate policies must also be considered. If a given utility has wholesale price structure which requires payment for a minimum quantity of water irrespective of whether the utility uses the water or not, the utility is encouraged to use the minimum amount even though it may have better management options. Traditionally, wholesale water contracts include these minimum purchase requirements. Some examples in the Bay Area are:

1. Contra Costa County Water District-United States Bureau of Reclamation Contract.

2. East Bay Municipal Utility District-United States Bureau of Reclamation Contract.

3. City of San Francisco Government Agency Resale contracts (numerous).

4. Santa Clara Valley Water District Municipal contracts (several).

5. Sonoma County Water Agency-Marin Municipal Water District Contract.

As an example, a typical conditional sales agreement between the City of San Francisco (the wholesaler) and a water distribution agency (the retailer) provides that for each billing period the retailer will pay for a minimum quantity of water stipulated in the agreement in a delivery schedule (which escalates annually) at rates from time to time set by the Public Utilities Commission of San Francisco. The agreement also sets a maximum delivery schedule limiting the wholesaler's obligation to service. At any point in time, the minimum delivery rate for which payment is required is always one-third of the maximum rate limiting the wholesaler's obligations. One way to eliminate the minimum purchase incentive and yet retain the very necessary fixed income the wholesaler requires would be simply to require the retailer to pay a fixed flat charge for water service. Rates could be surcharged one-half or one percent in all but critical years to create a drought reserve upon which to draw in critical dry years so that fixed charges could be relieved by 25 or 50 percent in such years. This approach would maintain the solvency of the wholesaler in critical dry years plus create the ability to tender an economic reward to help achieve water rationing goals that might become necessary. Some wholesalers might argue that minimum quantity payment schedules are necessary to assure proper scheduling for reservoir releases, power generation, and other operations, but scheduling need not be tied to an artificial minimum quantity payment schedule. The wholesaler could set up procedures requiring advance ordering where this might be a critical problem with reasonable penalties should improper scheduling cause a loss of revenue (power or other) to the wholesaler.

CURRENT STATUS OF WATER CONSERVATION PROGRAMS IN THE BAY AREA

Water conservation programs implemented by various Bay Area utilities are shown in Table III-2. Some of these programs were initiated directly in response to the drought, but many utilities had become involved in conservation activities prior to the drought. Three utilities have gained nationwide recognition because of their water conservation efforts:

1. East Bay Municipal Utility District--consumer education (especially at the grade-school level).

TABLE III-2

WATER CONSERVATION ACTIVITIES TAKEN BY MAJOR BAY AREA WATER UTILITIES IN 1974-1975 (PRIOR TO DROUGHT)

Activity	Alameda Co. FC & WCD	Alameda Co. Water Dist.	Calif. Water Service Co.	City of Antioch	City of Daly City	City of Fairfield	City of Milpitas	City of Mountain View	City of Napa	City of Palo Alto	City of Petaluma	City of Pittsburg	City of San Francisco	City of Santa Clara	City of Santa Rosa	City of Vacaville	City of Vallejo	Contra Costa Co. WD	East Bay MUD	Great Oaks Water Co.	Marin Mun. Water Dist.	North Marin Co. WD	San Jose Water Works	Santa Clara Valley WD	Sonoma Co. Water Dist.
Meter all services	-	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-
Eliminated declining block rates	-					x						x									x	x		-	-
Phasing out declining block rates	-		x				x		x	x						x		x						-	-
Have seasonal or peak demand rates	-																							-	-
Active leak detection program	-				x			x			x		x	x	x	x	x	x	x	x	x	x	x	-	-
Assist consumer in leak detection	-	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	-	-
Pressure regulators required	-	x	x	-				-	x	x		x		-	x	x	x	x	x		x	x		-	-
Develop or purchase w. c. info:																									
Bill stuffers		x	x		x						x							x	x		x	x			
Direct mail																		x							
Paid newspaper ads					x						x										x			x	
Paid radio spots																			x		x			x	
Paid TV spots																		x	x		x			x	
Paid periodical ads																							x		
Demonstration booths																	x		x		x		x	x	
Community forums	x	x		x							x						x	x	x		x	x		x	
Speakers bureau	x	x							x		x				x		x	x	x		x	x		x	x
Materials developed for schools	x	x										x					x	x	x		x			x	
Retrofit devices:																									
Delivered free																					x	x			
Free at central location																					x	x			
Certain devices available at cost																					x				
New Construction--inside use:																									
Encourage use																			x		x	x		x	
Require use of certain devices																					x	x			
New Construction--outside use:																									
Encourage use																			x		x	x		x	
Require use of certain devices																					x	x			
Drought-tolerant landscaping																									
Encourage use	x			x								x						x	x		x	x		x	x
Demonstration garden																		x			x				
Sought w. c. legislation		x													x						x	x		x	
Sought building code changes																					x	x		x	

x, affirmative response
-, not applicable
w.c., water conservation

2. Marin Municipal Water District--drought management, retrofit programs, and conservation rates.

3. North Marin County Water District--water saving devices and techniques for new residential construction.

The drought has unquestionably accelerated water conservation progress and it can be expected that well-managed utilities will convert the liabilities of the drought into an asset by launching or greatly accelerating ongoing programs aimed at achieving reductions in unnecessary water use and better utilization of the water resource by use of more efficient devices and techniques and perhaps even modifying traditional concepts of western landscaping.

TWO MODEL PLANS FOR RESIDENTIAL WATER CONSERVATION

This section sets forth two alternative plans utilizing devices and design techniques suitable for reducing water use in both existing residences and new residential construction. It relies heavily on the experience of others and several references now available on the subject [References 7, 12, 15, 20, 21]. Because definitive data are meager or not available in the case of new construction, estimates of savings have been made. The estimates are believed to be suitably conservative; the actual savings may well be greater than presented.

A water savings plan based on two levels of implementation effort (and expense) was formulated for both existing and new construction. The two levels of implementation are termed moderate and maximum and, because of basic data constraints, have been determined for single-family detached units and multiple units, with the latter category defined to include single-family attached and apartment units.

In view of the experiences of others and the magnitude of the number of dwelling units involved in the Bay Area (on the order of 1.6 million), the part of the plan associated with existing construction requires that the plan be simple, rely on volunteer labor for assembly work and any distribution of kits, and rely on occupant installation of devices. Meeting these three criteria eliminates most of the retrofit paraphernalia existing on the market today and limits the retrofit portion of the plan to the type of kits pioneered by the Washington Suburban

Sanitary Commission and the Marin Municipal Water District, with the only essential difference between moderate and maximum implementation being the level of effort employed to get the kit into the hands of the consumer.

In developing that part of the plan for new residential construction, the numbers are not overwhelming (on the order of 80,000 new units annually) and incremental labor and materials costs can be accommodated by inclusion in initial construction costs. When data did not exist for making a reasonable estimate of water savings, savings were theoretically estimated or assumed negligible for that element.

Elements

Elements from which the model plans were formulated are discussed below:

Retrofit Kit. These kits consist of four one-quart plastic bottles, one 3-gpm shower flow-control unit, two dye tablets for toilet tank checking, and instructions and water saving tips assembled in plastic bags for hanging on door knobs.

Estimated cost (based on large volume purchases):

4 bottles @ 9¢ ----------------	$0.36
2 dye tablets @ 5¢ ------------	0.10
1 shower insert @ 45¢ ---------	0.45
plastic bag and instructions --	0.09
	$1.00/kit

Estimated gross savings for participating household:

bottles -----------------------	2.3 gpcd*
shower insert -----------------	6.8 gpcd
dye tablets -------------------	no credit
total	9.1 gpcd

Net savings (population as a whole):

moderate implementation -------	1.7 gpcd
maximum implementation --------	4.1 gpcd

*gallons per capita per day

The plastic bottles are outboard motor oil containers, measuring 4-1/4 x 1-3/4 x 8-1/2 inches and capable of holding one quart. By purchasing end-of-run, mixed dye, or massive volumes, costs are kept to a minimum. The bottles, often weighted with small rocks or pea gravel, are placed in the toilet tank to displace tank water that would otherwise drain from the tank when flushed. No adjustment of flushing apparatus is necessary (although the consumer should be cautioned to check the float controlled overflow level to be sure no overflow is occurring). The life of the bottles can be expected to outlast the metal parts in the toilet tank. It has been found that two bottles work well in most standard toilets, leaving a sufficient quantity of water in the tank to assure adequate performance. Theoretical savings for the bottles, assuming two per tank, five flushes per person per day, and applying a 10 percent reduction factor to account for absences from home and other factors, is 2.3 gpcd.

The shower flow-control insert suggested is one that controls delivery rate to 3 gpm (a shower will deliver 5 gpm or more when fully opened). Several devices are available, but those made of hard plastic for long life are recommended. One device (perhaps others) can be used with all types of shower head arrangements (including ball type on gooseneck provided care is taken during installation), has the physical characteristics of a venturi tube, and (according to the manufacturer's curves) has satisfactory delivery versus pressure characteristics. Assuming a typical shower is throttled by the user to deliver about 4.5 gpm, a five-minute daily shower, and a 10 percent reduction factor to account for absences and other variables, a theoretical saving of 6.8 gpcd is estimated.

The dye tablets, made of harmless food coloring, can be purchased in effervescent form for quick dissolution in the toilet tank to determine if tank water is escaping past the rubber ball or flapper valve at the base of the tank. If grit is not causing the problem, replacement of the valve is probably in order. The key to effectiveness of this test is explicit and clear instructions on how to perform the test and what steps should be taken to eliminate the leak if one is found. No savings are estimated for use of the dye tablets due to lack of information.

The theoretical savings for the home utilizing a kit is 9 gpcd, but utility surveys show that 100 percent utilization or penetration cannot be expected. Results of the meager survey information available are presented in Table III-3.

TABLE III-3

CUSTOMER UTILIZATION OF
WATER CONSERVATION DEVICES

Utility	Method of Distribution	Responses Analyzed	Survey Response %	Had Installed, % Bottles	Had Installed, % Shower Inserts
WSSC	Door-to-door	6,240	3	30	-
MMWD*	Central Distribution	1,000	52	79	42
NMCWD	Door-to-door upon request	3,000	72	60	30

*Based on "preliminary" data on single-family units compiled by California State Department of Water Resources. Final results may differ.

Taking the information presented in Table III-3 and based on interviews of various Bay Area utilities which have implemented retrofit programs, it is estimated that a moderate water conservation program implemented in a noncrisis situation and utilizing central distribution points could achieve 30 percent utilization of bottles and 15 percent utilization of shower inserts. This is estimated to yield an overall savings of 1.7 gpcd. Assuming a maximum-effort campaign utilizing volunteers to deliver kits door-to-door (preferably to occupants requesting them in response to a pre-mailed offer), it is estimated that penetration of 75 percent and 35 percent for bottles and shower inserts, respectively, could be achieved, yielding an overall savings of 4.1 gpcd.

Low-Flush Toilets. Low-flush toilets (required in most new residential construction commencing January 1, 1978, pursuant to a bill drafted by a Bay Area utility) are designed to

operate with approximately 3.5 gal/flush. Many manufacturers, both long-line (serving mainly the retail industry) and short-line (serving mainly large subdivisions and multiple developers), now make low-flush toilets certified as to performance by the International Association of Plumbing and Mechanical Officials, a self-policing trades association. Low-flush models are rapidly becoming the standard for the industry and the slightly higher cost once associated with them has vanished according to both wholesalers and retailers. Assuming 5.5 gal/flush for the old standard toilets, five flushes per day, and a 10 percent reduction factor to account for extended absences from home and other variables yields estimated savings of 9 gpcd. Added cost to purchase and install a water saving toilet in new construction is assumed to be zero.

Shower Flow Control. Shower flow controllers with variable orifice designed to deliver 3 gpm even though feed line pressure might vary and constructed of chrome-plated brass, or shower heads featuring built-in flow control, are recommended for new residential construction. Having better delivery rate versus pressure characteristics and designed to avoid noise problems, these units are recommended over most inserts. The savings in water are estimated to be the same as for plastic inserts, or 6.8 gpcd. Purchase price varies depending on quantity and type, but $5 per device is assumed to be a representative average. Additional cost to install these fixtures would be negligible when ordered for new construction.

Faucet Flow Controllers. Faucet flow controllers with similar features as noted for shower flow control, equipped with an aeration or laminar-flow feature, and delivering water at 2 gpm maximum are suggested for both kitchen sink and lavatory. Water savings have been estimated [Reference 22] at 0.5 gpm at each station. Purchase price varies based on quantity and type, but $5 per device was selected as a representative average cost. Additional cost to install this type of fixture would be negligible when ordered for new construction.

Hot-Water Pipe Insulation. Hot-water pipe insulation will reduce the time for delivery of hot water, and hence reduce water waste. Slit-foam tubing that can be relatively easily applied during construction is least expensive. Energy for heating water is also saved. Typical water savings for a

family of three are estimated at 1.0 gpcd. Price of insulation installed in new construction, based on 62¢/ft (materials plus labor), is estimated at $75 for a single-family unit and $38 for a multiple unit (due to shorter hot-water run).

Shower Cut-Off Valve. This valve, mounted in-line behind the shower head or purchased as an integral part of the shower head, provides the consumer the option of saving water by taking the "navy shower" approach (wet up--shut off--lather up--turn on--rinse off) and readily terminating and starting flow without fear of changing temperature setting. No water savings are credited to this device due to lack of data. Added cost to install this device in new construction is estimated at $5 per device.

Thermostatic or Other-Type Mixing Valve. This valve can be installed on the kitchen sink, lavatories, showers, and bathtubs. This device normally employs a bimetalic coil to enable single faucet operation for selection of volume and temperature. Hunting for desired temperature is greatly reduced; time is not wasted in the shower adjusting temperature to compensate for pressure variations in line pressure; "add water to gain correct temperature" syndrome is eliminated; and instant shut off and turn on without changing temperature setting is possible (on some valves). Water savings are estimated at 1.0 gpcd. Additional cost for unit installed at lavatory where it is not normally offered in new home construction is estimated to be $30 per fixture.

Pressure Regulators (Individual Services). Variations of pressure inherent in water systems can be controlled by installing pressure regulators on the service line entering the dwelling. When new development will receive pressure greater than 80 psi, regulators should be required because most toilet manufacturers claim fixture components will deteriorate at pressures exceeding this level and will develop leaks at the float shut-off valve. Some appliances also suffer from high pressure. Some utilities and governmental agencies, as a water saving measure, now require pressure regulators wherever service pressures exceed 60 psi. No added cost is assumed for water conservation because such a policy is good utility operational practice and because only a very limited portion of new development will be faced with the problem. Thus, no water saving credit is estimated.

Trickle-Drip Irrigation. This type of irrigation has come of age and numerous product lines are now on the market. Little data exist on recorded savings in residential situations, but homeowners who have installed a system extol its virtues: greatly-reduced water consumption because water is placed where its needed and nowhere else, more abundant and attractive growth, much-reduced weeding, less cultivating to break up ground hardened by sprinkler pounding, more efficient utilization of fertilizer, and no need for a plumber to install it. Tests of drip irrigation for commercial agricultural applications indicate efficiencies of 80 to 85 percent compared to typical sprinkler efficiencies of 60 to 66 percent, which includes leaching requirements [Reference 23]. Drip irrigation could save the home gardener 25 to 50 percent of his irrigation water, according to several sources [References 24 and 25].

Cost of installing a system for home landscape is estimated to range from $100 to $200 depending on type of equipment and size of area. Although agricultural applications have had some problems with bacterial growth and clogging, this apparently has not been a problem where potable water, containing extremely low turbidity and residual chlorine, is available. Information on the useful life of a drip system is not available, although use of drip in agriculture has expanded rapidly since its introduction on a five-acre test plot of avocados in San Diego County in 1970. At the International Drip Irrigation Conference, July 1974, it was estimated for San Diego County that 215,000 acres will be under drip irrigation by 1979, and that 100,000 acres were currently under drip irrigation. For single-family home use, it is estimated that two drip irrigation systems (one for the front yard and one for the backyard) consisting of a 1-3 station timer, two electric valves, two anti-siphon devices, two flow-control valves, two filters, 200 feet of polyethylene tubing, 50 emitters, and miscellaneous assembly tools and plugs would cost $125. Homeowner installation is assumed. Based on an assumed water savings (mainly in elimination of over application) of 40 percent and an assumption that shrubs, trees, and other border plantings account for 10 percent of outside water use, it is estimated that outside water savings of four percent would be achieved.

For multiple dwelling units, the size of system per dwelling unit would be much smaller, but labor costs must be added because landscaping irrigation systems are now normally

installed by developers of multiple units. It is estimated that the total cash outlay for the developer per unit would be about the same, or $125.

Automatic Sprinkler Systems. This element, consisting of automatic sprinkling systems featuring slow-rate heads on slope and clayey areas and preparation of soil beneath turf areas, needs little explanation except to remark that the slow-rate heads are the only component of this system that deviates from normal systems now installed in multiple dwelling projects. It has been reported [Reference 12] that the extra cost for these heads is to improve applied water penetration in soils with low infiltration capacities and on slopes. In the case of most single-family residences, automatic timers are not ordinarily utilized; the additional cost of these is estimated at $65. Adequate preparation of soil before planting a lawn is usually observed by the homeowner, but in most cases ignored by the developer of multiple units. Adequate soil preparation normally consists of plowing topsoil and adding soil amendments as necessary, mainly nitrolized organic materials to assure a suitable environment for turf and to avoid excessive runoff problems. The cost for a typical multiple unit is estimated at $52 per unit (assuming 2,000 square feet of turf area per unit and adequate topsoil to start with). Water that will be saved by use of timer-controlled sprinkler systems irrigating turf grown on a well-prepared soil bed is conjectural, but coupled with an ongoing consumer education program, it is assumed that the savings would approximate at least one-half of the amount of water overapplied at present, which is estimated [Reference 15] at 20 percent. Therefore, assuming that about 90 percent of outside use is for lawn irrigation, a savings of nine percent in outside use is estimated.

Drought-Tolerant Landscaping. Drought-tolerant plants, including many beautiful Mediterranean species as well as the more subtle California natives, hold promise for achieving tremendous savings in outside water use as well as reduced maintenance costs. The subject is too diverse to attempt estimating costs and savings; however, consumer education programs should encourage use of drought-tolerant alternatives to the post-1850 greensward landscaping tradition imported to California. A growing list of references is available on this subject and utilities should take the lead disseminating this information to consumers. The drought has created an expanding market for drought-tolerant plants

that should increase the availability, improve the quality, and reduce the price of this type of nursery stock.

North Marin County Water District reports the developers for two projects have agreed to develop landscape plans around a drought-tolerant planting theme. North Marin County Water District plans to monitor and report on water savings and homeowner maintenance costs. For the two projects that will be installed in 1978 it will take two to three years for landscaping to become established.

A summary of water saving elements, amount of savings, and costs is shown in Table III-4.

Summary of Model

The moderate and maximum plan as it relates to existing residential development is summarized in Table III-5. As noted earlier, the same kit is employed for each plan with only the method and effort put into distributing the kit varied (i.e., distribution centers where consumers would pick up kits for the moderate plan and door-to-door distribution for the maximum plan). For new residential construction, water saving elements employed for each plan are shown in Table III-6, estimated water savings are shown in Table III-7, and costs are shown in Table III-8. Only savings and costs associated with use of the various elements over common practice existing in the construction business currently are credited and included.

WATER CONSERVATION BY COMMERCE AND PUBLIC AUTHORITY

Water used by commercial establishments and public agencies is principally for sanitation purposes (public and employee restroom facilities, dishwashing, clothes washing, etc.) and for irrigation of landscaping, playing fields, and parks. Therefore many of the water saving techniques applicable for residential customers are equally applicable to commercial and public authority uses. Because of the scale of certain public and commercial users, the utility should work with especially large customers on a case-by-case basis to achieve long-term conservation. Others can be approached by special class mailings.

TABLE III-4

WATER CONSERVATION ELEMENTS, SAVINGS, AND COSTS

Measure	Estimated Water Savings		Added Cost[b], $
	gpcd	%[a]	
Retrofit kit; 4 bottles, shower flow control, dye tablets, and information	9.1[c]	7.2	1 ea.
Low-flush toilets, 3.5 gal/flush	9.0	7.1	0
Shower flow control, 3 gpm variable orifice	6.8	5.4	5 ea.
Faucet flow control with aerators, 2 gpm	0.8	0.6	5 ea.
Hot-water pipe insulation	1.0	0.8	0.62 /ft
Shower cut-off valve	unknown	unknown	5 ea.
Thermostatic mixing valve	1.0	1.0	30 ea.
Pressure regulator, where service >80 psi	unknown	unknown	45 ea.
Trickle-drip irrigation, shrubs		d	
Single-family unit			125[e]
Multiple unit			125[f]
Automatic sprinklers, timers, slow-rate heads (where needed) and soil preparation-turf areas		g	
Single-family unit			65
Multiple unit			52

TABLE III-4
(Continued)

WATER CONSERVATION ELEMENTS, SAVINGS, AND COSTS

[a]Savings as % of average residential water consumption for the Bay Area (excluding San Francisco but including a proportionate share of unaccounted-for water), 126 gpcd.

[b]Cost over and above materials currently utilized.

[c]Corrected for penetration effectiveness. This number reduces to: moderate implementation effort, 1.7 gpcd; maximum implementation effort, 4.1 gpcd.

[d]Estimated at 4% of outside use.

[e]Excludes labor for installation.

[f]Includes labor for installation.

[g]Estimated at 9% of outside use.

TABLE III-5

WATER CONSERVATION MEASURES AND
ESTIMATED WATER SAVINGS FOR
EXISTING RESIDENTIAL DWELLINGS

Measure	Estimated savings per installation gpcd		Implementation %		Overall savings gpcd	
	Moderate	Maximum	Moderate	Maximum	Moderate	Maximum
Plastic quart toilet tank displacement bottle (2 per tank)	2.3	2.3	30	75	0.7	1.7
Shower flow control insert (3 gpm)	6.8	6.8	15	35	1.0	2.4
Total					1.7	4.1

Some of the more unique conservation opportunities to explore include the following:

1. Use recycled water to cool compressors utilized in many commercial applications (i.e., refrigeration systems, some air conditioning systems, etc.).

2. Use tensiometers for more definitive irrigation scheduling at parks and playgrounds.

3. Install pressure reducing valves (50 psi maximum at highest fixture).

4. Use trickle-drip irrigation for appropriate landscaping and in nurseries.

5. Encourage routine plumbing and fixture inspections.

6. Increase pressure on car-wash nozzles, but cut back on delivery or shorten cycle.

TABLE III-6

WATER CONSERVATION ELEMENTS SELECTED FOR MODEL PLANS FOR NEW RESIDENTIAL DEVELOPMENT

Element	Moderate		Maximum	
	Single Family	Multi-Family	Single Family	Multi-Family
Low-flush toilets, 3.5 gal/flush	x	x	x	x
Shower flow control, 3 gpm, variable orifice	x	x	x	x
Faucet flow control with aerators, 2 gpm				
Kitchen sink	x	x	x	x
Lavatories	x	x	x	x
Hot-water pipe insulation			x	x
Shower cut-off valve	x	x	x	x
Thermostatic mixing valve				
Kitchen sink	x	x	x	x
Lavatories			x	x
Tub/shower	x	x	x	x
Pressure regulator if pressure >80 psi	x	x	x	x
Trickle-drip irrigation of shrubs, trees			x	x
Automatic sprinklers, timers, slow-rate heads (where needed) and soil preparation in turf areas			x	x

7. Change emitters in dishwashing machines.

8. Improve control of showers in public schools.

9. In employee restrooms, adjust flush valves to reduce the power flush.

10. Synchronize fire department wet drills with water utility pipeline flushing operations.

TABLE III-7

ESTIMATED MODEL PLAN WATER SAVINGS
FOR NEW DEVELOPMENT

Element	Moderate Plan		Maximum Plan	
	Single Family	Multi-Family	Single Family	Multi-Family
Inside, gpcd				
Low-flush toilets, 3.5 gal/flush	9.0	9.0	9.0	9.0
Shower flow control, 3 gpm, variable orifice	6.8	6.8	6.8	6.8
Faucet flow control with aerators, 2 gpm	0.8	0.8	0.8	0.8
Hot-water pipe insulation	-	-	1.0	1.0
Shower cut-off valve	*	*	*	*
Thermostatic mixing valve	*	*	1.0	1.0
Pressure regulator if pressure >80 psi	*	*	*	*
Subtotal, gpcd	16.6	16.6	18.6	18.6
Outside, % of outside use				
Trickle-drip irrigation of shrubs and trees	-	-	4	4
Automatic sprinklers, timers, slow-rate heads (where needed) and soil preparation in turf areas	-	-	9	9
Subtotal, % of outside use	0	0	13	13

*Required in plan but no credit given.

TABLE III-8

ESTIMATED ADDED COSTS OF MODEL WATER SAVING PLANS FOR NEW DEVELOPMENT (dollars)

Element	Moderate Plan		Maximum Plan	
	Single Family	Multi-Family	Single Family	Multi-Family
Low-flush toilets, 3.5 gal/flush	0	0	0	0
Shower flow control, 3 gpm, variable orifice (2)	10	10	10	10
Faucet flow control with aerators, 2 gpm				
Kitchen	a	a	a	a
Lavatories (2)	10	10	10	10
Hot-water pipe insulation	0	0	75	38
Shower cut-off valve (2)	10	10	10	10
Thermostatic mixing valve				
Kitchen	a	a	a	a
Lavatories (2)	-	-	60	60
Shower-tub (2)	a	a	a	a
Pressure regulator if pressure >80 psi	a	a	a	a
Trickle-drip irrigation of shrubs, trees	-	-	125[b]	125[c]
Automatic sprinklers, timers, slow-rate heads (where needed) and soil preparation in turf areas	-	-	65[b]	52[d]
Total Cost Per Unit	30	30	355	305

[a]No charge included since device is in normal use today.
[b]Assumes homeowner installation, no labor included.
[c]Assumes developer installation, labor included.
[d]Includes soil preparation only as other costs associated with this element normally incurred.

11. Meter all public agencies and eliminate any discount rates.

12. Drill new wells or reactivate old wells where groundwater is available. Blending with higher quality water may be appropriate where quality is important, such as in commercial laundries.

13. Convert median strips to low maintenance, low water use ground covers, cobblestones or bricks, or install subsurface irrigation systems.

14. Encourage elimination of "running water" situations (e.g., ice cream dipper pots, dental office basins).

15. Encourage use of swimming pool covers.

16. Encourage use or selection of more efficient appliances and fixtures at time of replacement.

As part of its consumer education program, the water utility should work on a case-by-case basis with its very large commercial and public agency customers and get pertinent information into the hands of smaller water-use customers. It is estimated that such efforts would produce at least a five to 10 percent savings.

WATER CONSERVATION BY INDUSTRY

Water used by industry falls into three categories: cooling water; process water; and other water, including water used for irrigation of landscaping and sanitation purposes. Regarding the last category, refer to the section on commercial water conservation as much of that section also applies here.

Conversion of once-through cooling to a closed system is often economically feasible for the larger industries. Often the cooling water could be reused for such activities as outside irrgation. In some cases 24-hour continuous cooling for electrical machines can be eliminated by relating cooling requirements to production schedules.

The first step in reducing the amount of process water is to relate water use to production. This relation isolates when and where water is being used and indicates where water is being

wasted. Substantial reductions in water used for clean-up can normally be made. Recycling water for a subsequent use can also produce savings.

In the heavily industrialized East Bay subregion one local water agency, East Bay Municipal Utility District, has been working closely with its 150 largest customers since July 1976 helping them to reduce water use. Some are implementing recycling programs and reducing waste of water. This is due in part to the 1976-1977 water rationing and in part to recently increasing costs of wastewater treatment. Because of these efforts, the District is expecting a permanent reduction in water use by these 150 customers of about 15 to 20 percent [Reference 26]. Because these savings are associated with the larger customers, an overall five to 10 percent savings in total industrial water use in the Bay Area appears feasible.

Reducing Unaccounted-for Water Use

Unaccounted-for water use includes distribution system losses due to leaks, unmetered water delivered through fire hydrants, and water used in flushing of water mains or sewers. To reduce this category of water use, water utilities can improve their leak detection procedures and meter all or nearly all other water use. Of 22 water distribution agencies surveyed in the Bay Area, two thirds had an active leak detection program; the remainder fix leaks once they are reported.

Results of a survey made by the California Department of Water Resources, Central Division, on water system efficiencies are presented in Table III-9. The efficiencies shown indicate the improvements that were achieved after programs were implemented to reduce leaks and other unaccounted-for water. The lower the initial efficiency, the larger the improvement that was realized. To increase efficiency beyond 95 to 98 percent in order systems would probably require replacing many water mains--a practice which is probably not justified based upon the incremental amount of water saved and the high replacement cost. Using the data presented in Table III-9, a least-squares regression curve was developed for use in predicting system improvement. The relationship is:

$$\text{Improvement, \%} = 287 - 62.8 \ln (\text{Existing System Efficiency, \%})$$

TABLE III-9

INCREASE IN WATER SYSTEM EFFICIENCY*
AFTER SYSTEM IMPROVEMENT
(percent)

Water Agency	Prior Efficiency	Present Efficiency	Increase
5,000 Connections and More			
Belmont CWD	94	97	3
City of Pleasanton	98	99	1
North Coast CWD	75	90	15
City of San Bruno	96	98	2
Marin Municipal WD	85	90	5
City of Santa Clara	90	95	5
San Jose Waterworks	91	93	2
500 to 5,000 Connections			
Stinson Beach CWD	85	98	13
City of Brisbane	88	95	7
City of Calistoga	65	70	5
City of Scotts Valley	70	92	22
Calaveras CWD	80	94	14
San Juan Sub. WD	85	95	10
Westborough CWD	91	94	3
Coastside CWD	92	94	2

$$\text{*System efficiency} = \frac{\text{Customer Delivery}}{\text{Input to System}} \times 100$$

Source: California Department of Water Resources

This equation predicts an increase of 8.5 percent for an existing efficiency of 85 percent and an increase of five percent for an existing efficiency of 90 percent.

BALANCING "WATER BUDGETS" IN CRITICAL DRY YEARS

When a water utility finds itself facing a long-term shortage of supply which cannot reasonably be resolved by emergency supplies or interties with other utilities, it has no option but to balance its water budget by means of rationing water. In this process, the utility must also make critical decisions on the minimum factor of safety it can accept in carry-over storage.

The first year of the current drought, winter of 1975-1976, brought rationing to Marin Municipal Water District (MMWD). The reserve capacity in MMWD's supplies had been essentially eliminated by controversies over water supply, environmental issues, costs, and land-use issues which had been occurring since the early 1970's. These controversies had delayed expansion of the water supply system. In early 1976, MMWD launched a mandatory rationing program which essentially banned outside sprinkling and called for 25 percent reductions in use by nonresidential consumers. Overall goal of the plan was to achieve a 25 percent reduction in normal annual water use. By year's end, District customers had responded with a net annual reduction of 27 percent. Officials of the District also noted that seasonal summertime demands had been cut in half.

The drought continued into the winter of 1976-1977 and presented most Bay Area utilities with the same situation MMWD faced the year before. As a result most utilities had no option but to implement mandatory rationing programs designed to reduce consumption by from 25 to 35 percent. For MMWD, water reserves dwindled to the point where extraordinary rationing. With the cooperation of 13 agencies, an emergency supply was piped to the District across the Richmond-San Rafael Bridge to take water from the EBMUD system. The water for MMWD was made available to EBMUD from the State Water Project. In addition the District was forced to impose rationing measures calling for a 57 percent overall reduction in normal annual water use. Since the more stringent rationing program started, consumers of the District have responded by dropping use an extraordinary 63 percent. In nearly every instance where mandatory rationing was requested in the Bay Area, the consumers responded by reducing water use even further.

Of all the debate that has gone on regarding the various rationing programs, most water agencies agree on one key point; namely, rationing can only be achieved through the voluntary commitment of the consumer, and to get that commitment, the utility must

communicate the shortage problem and required rationing solution to the consumer. In 1976 the burden of doing this in the MMWD service area fell squarely on the utility and the utility performed. There was indeed tremendous media coverage, but this, except for the local media, was essentially the outside "world" looking in out of curiosity and interest. In late winter of 1976-1977, media coverage greatly expanded both in terms of geography and intensity. The front pages of Bay Area newspapers for weeks carried story after story about the drought. Television stations organized special drought coverage teams and the media literally flooded the consumer with information on the problem and ways and means to conserve water. Many consumers, previously unaware of where their water came from and where their meter was located, became instant experts on how to read the meter, convert cubic feet to gallons, how much water a toilet flush takes, and so forth. There is absolutely no doubt of the service the media played in communicating to the public. The information provided by the utilities is the principal reason consumers reacted so quickly and positively to curtail use and live within and, in almost every case, go beyond what was requested of them by the utilities. Some utilities, unprepared to raise rates to equalize revenue due in normal years and required to meet fixed expense, were even caught by surprise. Water rationing has been overwhelmingly successful throughout the Bay Area, as shown in Table III-10.

Types of Rationing Programs

Under the constraint of limited time, utilities rapidly formulated and implemented rationing programs. In retrospect, some managers report that better coordination and agreement between utilities on certain points, especially penalty fees and shut-off policy, would have been desirable, but most report time and events simply did not permit this.

In reviewing the various mandatory rationing programs that were developed, several distinct forms emerge:

1. Type A--Percentage Reduction (compared to normal years use in a similar billing period).

2. Type B--Seasonal Allotment (a per capita or per home allotment which goes up in summer and down in winter).

TABLE III-10

WATER RATIONING GOALS AND PERFORMANCE OF REPRESENTATIVE AGENCIES

Agency	Goal[a]	Actual Performance[b]
Alameda County Water District	25%	30%
Contra Costa County Water District[c]	30	21
Daly City, City of	25	29
East Bay Municipal Utility District	35	31
Hayward, City of	25	36
Marin Municipal Water District	57	63
North Marin County Water District	30	38
San Francisco, City of	25	28
San Mateo, City of	25	35
Santa Clara Valley Water District	25	23
Santa Rosa, City of	30	37
Sunnyvale, City of	25	28
Arithmetic average (not weighted)		32%

[a]Current program goals as reported by agency

[b]For first 6 months of 1977 compared to first 6 months of 1976 as reported by Governor's Emergency Task Force. Note most programs were not implemented until March 1 or later so cumulative rationing performance under these programs is measured from the date of inception is 10% to 20% higher than indicated on list.

[c]Treated Water Division of CCCWD.

3. Type C--Fixed Allotment (per capita or home allotment based on calculated need).

4. Type D--Sprinkler Ban.

Water agencies unanimously concede that no given program is completely equitable to all and emphasize the need for an orderly and quick procedure to handle valid exceptions or variances. Usually common to all programs is prohibition of obvious wasteful practices (allowing a leak to go unrepaired, allowing water to run off to a gutter or ditch, washing sidewalks and driveways, etc.).

The programs implemented may or may not provide for penalty charges for usage outside of allotments and many water agencies are coming to the conclusion that penalty rates (at least in the case of the current and well-recognized widespread drought, and in situations where rationing on the order of 30 percent is required) may not be required to achieve rationing goals. If a penalty charge system is utilized, it usually takes the form of an inclining block commodity rate. Also most programs provide for shut-off of service in the event of continued violation with some making the possibility rather remote (i.e., two or more warnings first) and some calling for shut-off after one notice. All programs provide for immediate restitution of service upon payment of a fee or in some cases after installation of a flow-restricting orifice. Furthermore, most programs implemented provide for at least some water for construction so that sector of the economy is not impacted more severely than others. Lastly most programs handle nonresidential rationing (at least with respect to nonirrigation use) on the basis of some required percentage cutback. Often multiple residences are placed on a percentage of past usage. Typically commerce and industry in general, especially certain elements that are extremely sensitive to water reductions in terms of impact on production and employment, are not requied to cut back as much as consumers who have significant irrigation demand. State law, although placing water used for sanitation, firefighting, and domestic use at the top of the priority list, permits public- and privately-owned utilities alike to establish priorities and determine allocations among other purposes as long as customers within a given class are not treated differently (Water Code Section 354). Most policy-making boards faced with the necessity of rationing have endeavored to formulate a plan which will achieve the required savings, will be fair, and yet do the least amount of overall economic harm.

Selecting the type of rationing form best suited for a given residential population depends principally on three factors:

1. The amount of water available (Is there enough water for outside irrigation?).

2. The amount of seasonal variation in water consumption (usually a function of irrigation demand).

3. The degree of homogeneity in housing types.

Where water is in extremely short supply and little can be made available for irrigation (Marin Municipal Water District, for instance, where allotments are 37 gpcd), Type C, the fixed allotment approach, would appear to work best. Where water is available for some landscape irrigation, a plan that permits the consumer more water in the summer would appear best. Type A, a percentage reduction compared to a normal year's use in a similar billing period (most utilities are using 1976 as the base since records are most current and water consumption was representative of near normal patterns), or Type B, the seasonal allotment plan, would be best for this type of situation. A utility serving a broad range of housing types having significant numbers of dwelling units in high-density, low irrigation-demand apartments and housing projects, yet also serving a significant number of single-family homes in a suburban setting, has the most difficult problem of all to solve and still maintain equity between most residential customers. Given enough water for some landscape irrigation, Type D, a total ban on sprinkler irrigation, is probably the least popular plan. Some rationing plans that have been used in the Bay Area are shown in Table III-11.

Based on the accumulated evidence which is still accruing and has not as yet been scrutinized and analyzed for publication in professional journals, it would appear safe to conclude that given a serious enough water shortage and adequate communication to the consumer, an emergency rationing plan achieving between 25 to 50 percent reduction in residential water consumption can be implemented. It is doubtful that reductions of more than 25 percent can be imposed on commercial users, however, without extremely serious economic consequences.

Municipal Water Conservation Alternatives

In developing water conservation alternatives, the model plans for residential customers were supplemented with additional water savings for all water users including commercial, industrial, and public authority. It is estimated that a savings of five percent could be expected from a continuing public education on water conservation. An additional five percent savings could be expected if there was media publicity concerning a localized water shortage (not a major drought) in the Bay Area. Two other levels of water conservation were assumed to allow a projection of water requirements during a drought. Savings of 25 and 50 percent were assumed as reasonable estimates of the range in water rationing that might be necessary. Putting these two model

TABLE III-11

VARIOUS RATIONING PLANS

Type A--Percent Reduction (Compared to similar billing period a year ago)

Number of Connections: 13,000
Rationing Goal: 30% Date Implemented: March 1, 1977
Cumulative Savings (March 1-June 30): 46%
Residential Allotment: 70% of water used in similar billing period a year ago
Multiple Dwellings: Same
Nonresidential: Same with certain exceptions (i.e., laundries have no cut)
Water waste prohibited? Yes
New connection banned? No, but water for same deferred to April 1, 1978 (a definite date)
Rate penalties for exceeding allotment? No
Water banking allowed? No
Enforcement Procedure:
- 1st violation--written notice
- 2nd violation--water shut-off* ($30 fee to reconnect)
- 3rd violation--water shut-off* ($50 fee plus installation of orifice to reconnect)

*Sprinkler use may also be banned.

Type B--Seasonal Allotment

Number of Connections: 40,000
Rationing Goal: 30% Date Implemented: April 20, 1977
Cumulative Savings (April 20-June 30): 42 %
Residential Allotment:

1976 Average Daily Use	Allotment
< 180 gpd	180 x SAF
180 to 300	(180 + 75% of "excess 1976 use") SAF
300 to 900	(270 + 30% of "excess 1976 use") SAF
900 to 2000	(450 + 2.7% of "excess 1976 use") SAF
> 2000	480 x SAF

where:
- "excess 1976 use" refers to water used in 1976 over and above lower 1976 average daily use value, i.e., 180, 300, and 900 gpd respectively.
- "SAF" is seasonal adjustment factor which varies from 0.7 to 1.3 to reflect seasonal variations in water use.
- Customers' bills show what allowable allotment is for ensuing billing period

TABLE III-11
(Continued)

VARIOUS RATIONING PLANS

Type B (Continued)

Multiple Dwellings: 70% of average daily use in 1976 adjusted by the SAF
Nonresidential: 90% of average daily use in 1976 adjusted by the SAF except "irrigation only" services is 50% of average daily use in 1976 adjusted by the SAFR
where:
"SAFR" is seasonal adjustment factor for recreation use and varies from 0.4 to 1.7
Water waste prohibited? Yes
New connections banned: No, but service to new annexations or projects for which a tentative map has not been filed is denied.
Rate penalties for exceeding allotment? Yes
1st billing period (2 mo) 20% over allotment = regular rate
>20% over allotment = 10 times regular rate
Subsequent billing periods, any excess use of allotment = 10 times regular rate
Water banking allowed? Yes
Enforcement Procedure: Service may be shut off if allotment exceeded for two billing periods. Reconnection fee is $50.

Type C--Fixed Allotment

Number of Connections: 51,000
Rationing Goal: 57% Date Implemented: February 1, 1977
Cumulative Savings (February 1-June 30): 63%
Residential Allotment:
One person--49 gpcd
Two persons--43 gpcd
Three persons--41 gpcd
Four persons--37 gpcd
Five persons--34 gpcd
Six persons--33 gpcd
Seven persons--32 gpcd
Multiple Dwellings: same
Nonresidential: 65% of normal use in a similar billing period
Water waste prohibited? Yes
New connections banned? Yes

TABLE III-11
(Continued)

VARIOUS RATIONING PLANS

Type C (Continued)

Rate penalties for exceeding allotment: Yes
  For excess up to twice allotment--$10/100 cu ft
  For excess over twice allotment--$50/100 cu ft
Water banking allowed? Yes
Enforcement Procedure:
  Subsequent months--service shut off and reconnection upon payment of $35 fee (restrictor installed in special cases)

Type D--Sprinkler Ban

Number of Connections: 2,200
Rationing Goal: 30% Date Implemented: March 1, 1977
Cumulative Savings (March 1-June 30): 53%
Residential Allotment: No limit but irrigation must be done only by hand-held hose
Multiple: Same
Nonresidential: No limit except for car washes which were limited to 70% of use in a similar billing period one year ago
Water waste prohibited? Yes
New connections banned? No, but water not made available until emergency over
Rate penalties for exceeding allotment? No
Enforcement Procedure:
  1st violation--written warning
  2nd violation--citation issued for up to $500
  3rd violation--misdemeanor and water service shut off and restored for $25 and restrictor may be installed

residential water conservation plans and selected other overall water savings together resulted in the list of eight water conservation alternatives shown in Table III-12. The effectiveness of the water conservation alternatives in reducing residential water consumption in existing homes is based upon an estimate of how successful the implementation will be. The overall effectiveness of these water conservation alternatives is presented in Chapter VI.

AGRICULTURAL WATER CONSERVATION

Water conservation on the farm level can be achieved by leveling of land, shortening of irrigation runs, applying various sprinkler methods, and using low application rate techniques. Modern monitoring equipment, automatic controls, and advanced operation methods can also save substantial amounts of water. Additional saving of water can be achieved on the water district level by improving the distribution systems and reducing water losses. Conversion of open canal distribution systems to pipe and pressurized supply system would be the most important improvement.

Advantages of changing gravity irrigation systems to pressurized systems include the following:

1. Pressure irrigation systems make it possible to apply the right amount of water, application rates can be controlled over a wide range, and the overall distribution coefficient is constantly kept at high values.

2. The sprinkler and drip systems can be adapted to the lay of the land and the shape of individual plots.

3. Irrigation rates can be easily adapted to crops, soil, and climate.

4. Sprinkler and drip systems are easy to operate and unskilled labor may be employed to operate the systems.

A well-planned educational program for farmers and personnel in the water supply and distribution field is also an important factor for change to modern application and operation methods.

TABLE III-12

WATER CONSERVATION ALTERNATIVES

Alternative Number	Level of Conservation	Water Savings			
		Residential		Industrial-Commercial	Public Authority
		Inside	Outside		
1	Moderate Implementation of Devices				
	Existing Construction	1.7 gpcd	0	0	0
	New Construction	16.6 gpcd	0	0	0
2	Moderate Implementation of Devices + 5%				
	Existing Construction	1.7 gpcd + 5%	5%	5%	5%
	New Construction	16.6 gpcd + 5%	5%	5%	5%
3	Moderate Implementation of Devices + 10%				
	Existing Construction	1.7 gpcd + 10%	10%	10%	10%
	New Construction	16.6 gpcd + 10%	10%	10%	10%
4	Moderate Implementation of Devices + 25%				
	Existing Construction	1.7 gpcd + 25%	25%	25%	25%
	New Construction	16.6 gpcd + 25%	25%	25%	25%
5	Moderate Implementation of Devices + 50%				
	Existing Construction	1.7 gpcd + 50%	50%	25%	50%
	New Construction	16.6 gpcd + 50%	50%	25%	50%
6	Maximum Implementation of Devices				
	Existing Construction	4.1 gpcd	0	0	0
	New Construction	18.6 gpcd	13%	0	0
7	Maximum Implementation of Devices + 5%				
	Existing Construction	4.1 gpcd + 5%	5%	5%	5%
	New Construction	18.6 gpcd + 5%	18%	5%	5%
8	Maximum Implementation of Devices + 10%				
	Existing Construction	4.1 gpcd + 10%	10%	10%	10%
	New Construction	18.6 gpcd + 10%	22%	10%	10%

Efficient Irrigation Methods

Sprinkler and drip irrigation systems are more efficient in water distribution and water use than gravity systems. There are many types of these systems in operation, depending on soil conditions, type of crop, size of plots, as well as the relation of capital investment versus labor cost. These systems may be grouped into four general categories:

Portable Sprinkler Systems. In these systems the main lines, the laterals, and sometimes the pumps are portable. They are used mainly for infrequent and supplemental irrigation in big tracts. Capital investment is generally low but labor costs are high.

Semi-portable Sprinkler Systems. These systems consist of permanently buried mains, portable laterals, and permanent pump stations. In smaller plots the sprinkler systems may be connected to areawide pressure systems. There are several types of semi-portable systems available depending upon whether they are moved or dragged by hand, towed by tractor, or roll-moved systems supported on large wheels.

Permanent Systems. Buried pipelines are used for irrigating orchards and vineyards or at large farms where automation and remote control is incorporated into the system. These systems are used for permanent cultures like orchards and vineyards where it is difficult to move portable pipes. Capital costs in such systems are high and labor costs are low. In orchards the permanent systems are generally used with under-tree sprinklers; in vineyards however, the conventional overhead type is mostly used for irrigation and frost protection. The permanent sprinkler systems have also multiple use; they can apply fertilizers and chemicals for weed and insect control.

Drip Irrigation. Drip irrigation is a method of applying water by releasing it a drop at a time onto the soil through small orifices. Generally this method uses lower water pressures than sprinklers, an advantage where energy costs have increased rapidly. Drip irrigation is used on many crops, which fall generally into four groups: orchards, vegetables, vineyards, and ornamentals. Because the systems are costly, they are generally feasible only on high-value crops and not on field crops. Drip irrigation has also been used to irrigate soils and terrain that could not have been watered by other methods. In San Diego County there are areas

having an ideal climate for growing avocados, but with shallow soils on steep, rocky mountain slopes. Drip irrigation has made avocado cultivation possible in these areas that would otherwise remain rough mountain brushland.

In orchards only given areas around the trees are wetted; thus, water savings result from reducing the total evaporative surface, runoff, and deep percolation. Further water savings are obtained when the trees are young and do not cover the entire soil surface. The disadvantage of this method is that the orifices used are very small, and the irrigation water must be screened or filtered to remove any particles which might plug outlets. However with a method still so new, many new developments, modifications, and applications can be expected. New developments may result in systems that operate similarly to drip systems while using bigger orifices and no more pressure than that available in low-head pipelines supplying water for flood irrigation.

Automated and Computer-controlled Systems. In times of water shortage, and increasing labor and capital costs, a trend toward more automation can be anticipated. Electrically operated clocks to turn on systems at designated intervals, automatic metering valves to deliver any prescribed volume of water, and controls from buried tensiometers that prevent the system from turning on if there is already sufficient moisture in the soil are devices that have been used. These can be coupled with additional equipment to provide a totally integrated and computer-controlled irrigation system. Three types of information are collected and used in such systems:

1. Agricultural parameters such as soil moisture content, stage of crop growth, crop health, and effectiveness of recent irrigation.

2. Meteorological data, such as solar radiation, maximum and minimum termperatures, evaporation, rainfall, and wind movement.

3. Operational parameters such as flow rates, pressures, and unopened or burst valves.

The "MIR-1000" automatic irrigation control system recently developed in Israel consists of three major elements:

1. A master control station, containing the computer and its peripheral display and control equipment.

2. The field units, which execute instructions relayed from the master control, and which, in turn, relay status reports and field measurements to it.

3. A single, buried three-wire cable, which transfers instructions and power to the field units, and relays the status and field reports to the master control.

Costs of Irrigation Systems

The average per acre investment for the different irrigation systems at current (1977) prices are approximately the following:

Gravity Systems. The average leveling cost for one acre is $150 and the additional cost for pipes and other equipment is $50 to $100/acres. The total average per acre cost is therefore $225.

Portable Sprinkler Systems. The average cost per acre of a completely movable irrigation system, including a booster station to pump water from open ditches, is $250.

Permanent Sprinkler Systems. The average cost per acre of a permanent sprinkler system including a booster station is $700.

Drip Irrigation Systems for Vegetables. The average per acre cost of installing drip irrigation systems for vegetables and strawberries, including booster pumps and filters, is $900. The $200 difference between vegetables and orchard systems is related to the much longer footage of emitters needed for vegetables.

The useful lifetime of sprinkler and irrigation systems is 10 to 15 years, and annual depreciation cost, depending on the salvage value of the systems, is in the range of 10 to 14 percent.

According to one source [Reference 27], the high initial capital cost of permanent sprinkler and drip systems may be repaid in seven to 10 years from water saved, reduced labor, benefits of frost protection, better yields of higher quality crops, and other management savings.

Agricultural Water Conservation Methods at the County Level

Properly designed sprinkler and drip systems can provide uniform distribution of water and can reduce evaporation, runoff, and deep percolation losses. Well-engineered sprinkler and drip systems can be 85 percent efficient, as compared to most flood and furrow irrigation systems which are approximately 55 percent efficient. A water savings of 30 percent was assumed at the farm level as a result of changing existing irrigation patterns and converting gravity systems to pressurized systems.

Other water conservation practices such as automation, night irrigation, alternate middle irrigation, and similar methods may also save considerable amounts of water. At the irrigation-district level additional water savings can be achieved by improving the distribution system and reducing water losses. At present, the amount of water that would be saved by these methods cannot be estimated; therefore, an overall savings of five percent is assumed.

The replacement of gravity systems with pressure systems together with other conservation practices was evaluated on a county-by-county basis to allow consideration of such factors as terrain, composition of soils, crop distribution, existing irrigation systems, water cost, metering practices, meteorological conditions, automated controls, and the conversion of agricultural land to urban use.

The county-by-county evaluation and cost estimates are based on four assumptions.

1. It is assumed that 50 to 60 percent of the irrigated area which will remain in agriculture until the year 2000 will install more efficient irrigation systems. An additional assumption is that in the year 2000 five percent of the water will be saved by improved irrigation practices.

2. It is assumed that agricultural water conservation will not be implemented until the year 1980.

3. It is assumed that increases in on-farm efficiency and reduction of runoff and deep percolation will not have a significant effect on agricultural water supply. Farmers dependent upon these sources will have to reduce water use as well.

4. At present it is difficult to determine what types of pressure irrigation systems will be installed, i.e., movable sprinkler systems, permanent sprinkler systems, or drip irrigation systems. Assuming an even distribution between these three systems, an average installation cost of $500/acres is used.

5. The cost for additional, countywide improvements to achieve an overall five percent savings is estimated to be on the order of $50 per irrigated acres. These improvements and costs are applied only to that acreage projected to be in production in the year 2000. Projections of crop acreage are presented in Chapter IV.

Cost-effectiveness of investments is evaluated in Chapter VI.

Alameda County. The conversion of agricultural land to urban use and the relatively high wind speeds in the Livermore-Amador Valley are the two most important factors which limit the opportunity to replace gravity systems with pressurized systems. It is estimated that 2,000 acres of gravity system could be replaced by permanent sprinkler or drip irrigation systems. The predicted saving of water would be 1,500 acre-ft/yr. Applying the overall savings factor of five percent to the predicted irrigational water use in the year 2000, an additional 450 acre-ft/yr of water could be saved. The estimated cost for installing more efficient irrigation systems is about $1,000,000. The cost for the overall improvement will amount to $200,000 or a total investment of $1,200,000.

Contra Costa County. Approximately 50 percent of the irrigated area today uses gravity irrigation practices. The remaining 50 percent is irrigated with sprinkler systems. Because of power costs associated with sprinkler systems, it is assumed that only 30 percent of the gravity systems will be replaced by pressure systems. Based on this assumption, 6,000 acres will be provided with pressure systems, saving 5,200 acre-ft/yr of water. It is also assumed that improvements amounting to five percent will be made on the existing systems, saving an additional 5,000 acre-ft/yr. The total savings would amount to 10,200 acre-ft/yr. The cost of replacing 6,000 acres of gravity systems will amount to $3,000,000 and all the other improvements will be approximately $1,660,000. The total estimated cost for conserving 10,200 acre-ft/yr will be $4,660,000.

Marin County. Many small reservoirs supply water to the irrigation systems in this county. Approximately 35 percent of the irrigated land uses gravity irrigation methods and 65 percent uses movable sprinkler systems. There is some potential for water conservation practices in the county, and it is estimated that 300 acres of gravity and movable sprinkler irrigation systems will be replaced by permanent sprinkler or drip irrigation systems. This replacement would save 200 acre-ft/yr of water. Other improvements are estimated at five percent of the irrigational water use for the year 2000, amounting to 50 acre-ft/yr. The total amount saved would be 250 acre-ft/yr. The conversion to permanent sprinkler systems is estimated to cost approximately $120,000 and the overall improvement cost would be $20,000. Total cost is estimated to be $140,000.

Napa County. Two factors limit additional water conservation practices in this county: (1) the irrigation systems receive water only from limited local sources, and (2) recent large planting of vineyards have included, in general, permanent sprinkler or drip irrigation systems with automatic controls for frost protection. Therefore, the replacement of existing irrigation systems by more efficient ones for water conservation is not practical. However, a five percent conservation factor for different types of improvements (mostly automatic controls) was used. Such improvements would save approximately 1,000 acre-ft/yr of water. Applying the $50/acre improvement cost to the projected irrigated acres in year 2000 results in a cost of $625,000.

San Mateo County. Small reservoirs and wells supply the present irrigation systems in San Mateo County. Many small farms with old sprinkler irrigation systems depend on these limited local water sources. The irrigated areas are intensely cultivated and many high-value crops are grown. Greenhouses and nurseries have started to install drip irrigation systems, however. Drip irrigation systems could also be used for other crops, such as artichokes, but most of the farms are small and cannot afford to install the filters which are needed for drip irrigation systems. In this county, therefore, only overall water savings of five percent are assumed practical. The five percent water savings in the year 2000 will amount to approximately 500 acre-ft/yr. The estimated cost to achieve these savings will be $335,000.

Santa Clara County. The conversion of agricultural land to urban use is the most important factor limiting capital outlays for irrigation system improvements in this county. It is estimated that 50 percent of the irrigated area receives gravity irrigation and the other 50 percent uses movable sprinkler systems. A major portion of the vegetables are irrigated by sprinklers in the first growth period and thereafter, when the plants start to develop, by furrow irrigation. Many old orchards are not irrigated or do not use gravity irrigation methods; there are no permanent sprinkler systems in the county. The county plans to preserve 12,000 acres for permanent agricultural use, which should provide an incentive to replace gravity and movable sprinkler systems with permanent sprinkler and drip irrigation systems. An additional factor which limits implementation of water conservation practices is that many small farms are growing crops, mostly vegetables, associated with high production costs where the water cost amounts to only 10 percent of the total agricultural production cost. Assuming that 28,100 acres will be irrigated in the year 2000, it is estimated that 14,000 acres of permanent sprinkler systems will replace the present gravity system. The water savings on these 14,000 acres would be 9,600 acre-ft/yr. It is estimated that additional water savings by overall improvement in agricultural irrigation practices will amount to five percent, or 3,400 acre-ft/yr. The total water savings will amount to 13,000 acre-ft/yr. The installation cost of pressure systems on the 14,000 acres will be $7,000,000 and the cost for general improvements will be $1,400,000.

Solano County. In this county 75 percent, or 104,000 acres, of the irrigated area is still under gravity irrigation. The remaining 25 percent of the area is irrigated by sprinkler systems. Because the plastic emitters freeze in the winter, drip irrigation systems have not been installed in the county. It is estimated that approximately one-half of the area under irrigation, amounting to 70,000 acres, will install sprinkler systems and save approximately 60,000 acre-ft/yr of water. Other conservation methods, including repumping of tail water from the gravity systems, will conserve five percent of the required water for the year 2000, amounting to approximately 18,500 acre-ft/yr. The total amount of water saved would be 78,500 acre-ft/yr. The estimated cost of replacing 70,000 acres of gravity systems with pressure systems will amount to $35,000,000, and costs for the other improvements will be approximately $7,000,000. The total cost for conserving 70,500 acre-ft/yr in this county will amount to $42,000,000.

Sonoma County. Irrigation in this county is based on limited local water supply from wells and river diversions. Almost all the irrigation systems are pressure systems, comprised of approximately 50 percent movable sprinkler systems, 40 percent permanent sprinkler systems, and 10 percent drip irrigation systems. Automatic controls are used in many vineyards and several farmers use tensiometers. Water conservation in this county could be achieved by replacing movable sprinkler systems with permanent sprinkler systems or drip irrigation systems. Assuming that 12,000 acres of movable sprinkler systems would be replaced by drip irrigation systems, and by applying a 20 percent savings factor, approximately 4,400 acre-ft/yr of water could be conserved. Other conservation methods such as automation and improved irrigation practices would save an additional five percent of water, amounting to approximately 1,500 acre-ft/yr. The replacement cost for converting 12,000 acres from movable sprinkler systems to drip irrigation would be about $4,200,000. The cost for the overall improvement applied to the irrigated area predicted for the year 2000 will be $1,250,000. Consequently, the total cost of agricultural water conservation in Sonoma County would be $5,450,000.

CHAPTER IV

WATER USE IN THE BAY AREA

INTRODUCTION

Water users in the nine-county Bay Area are supplied by 80 different water distribution agencies. The majority of the water distributed by these agencies is provided by nine suppliers who develop the water locally, import it, or obtain it from State and Federal water projects. In 1975, the total annual water use in the nine-county Bay Area was 1,590 million gallons per day (mgd). Residential, commercial, industrial, public authority, and unaccounted-for uses comprised 59 percent of the total; agricultural use represented 41 percent.

Water-use projections were made through year 2000 for the nine-county Bay Area to evaluate the water savings that could be effected from various water conservation programs, to help in quantifying the potential for wastewater reclamation, and to assess the need for planned future water supply development projects. The projections were developed in sufficient detail to evaluate the effect of individual wastewater reuse projects, to identify potential water-deficient areas, and to determine the effectiveness of specific water conservation measures.

The water-use projections are based on the ABAG Provisional Series 3 Population, Housing, Employment, and Land-use Projections, adopted March 2, 1977, and revised in May 1977.

ABAG SERIES 3 PROJECTIONS

The Provisional Series 3 Projections are the third in a series produced jointly by ABAG and the Metropolitan Transportation Commission (MTC) since 1970. They project the growth and distribution of population, housing, employment, and land uses in the San Francisco Bay Region through the year 2000. Revised projections will be produced after a period of review by policy bodies of local agencies.

Two sets of projections are provided, using varying assumptions about both national and regional trends and local development policies. Regional development policies are not explicitly included, but will be used as bases for evaluating the impacts of alternative regional policies.

General assumptions underlying the Provisional Series 3 Projections are: (1) At the regional level, alternative sets of assumptions are made regarding national and regional demographic and economic trends; (2) At the subregional level, the projections reflect the current operating policies of local service and regulatory agencies whether or not they are expressed in the general plans of cities and counties; (3) Transportation assumptions about highway and transit facilities are based on the MTC regional transportation plan; (4) The projections assume that no major wars or natural disasters will occur; (5) Development of new technologies is not considered; (6) The projections do not include environmental and energy policies that may be implemented in the future; and (7) The projections do not reflect regional development policies.

The Provisional Series 3 Projections are not policy targets or goals, and should not be interpreted as a recommendation for a particular level or distribution of urban development. They are intended to provide information concerning a range of future conditions that will likely result from existing local policies and anticipated future growth.

These projections use 1975 as a base year and provide estimates of population, number of occupied dwelling units, employment, land use, and other parameters in each of 440 subregions, or zones, that cover the entire nine-county area through the year 2000. The 440 zones are delineated on Figure IV-1. Two alternative projections were developed--Base Case 1 and Base Case 2--to represent high and low predictions, respectively. The specificity of the Provisional Series 3 Projections provided the means for making detailed water-use projections not previously possible on a regional scale.

Information from the Provisional Series 3 Projections used in making water-use projections are summarized by county in Table IV-1.

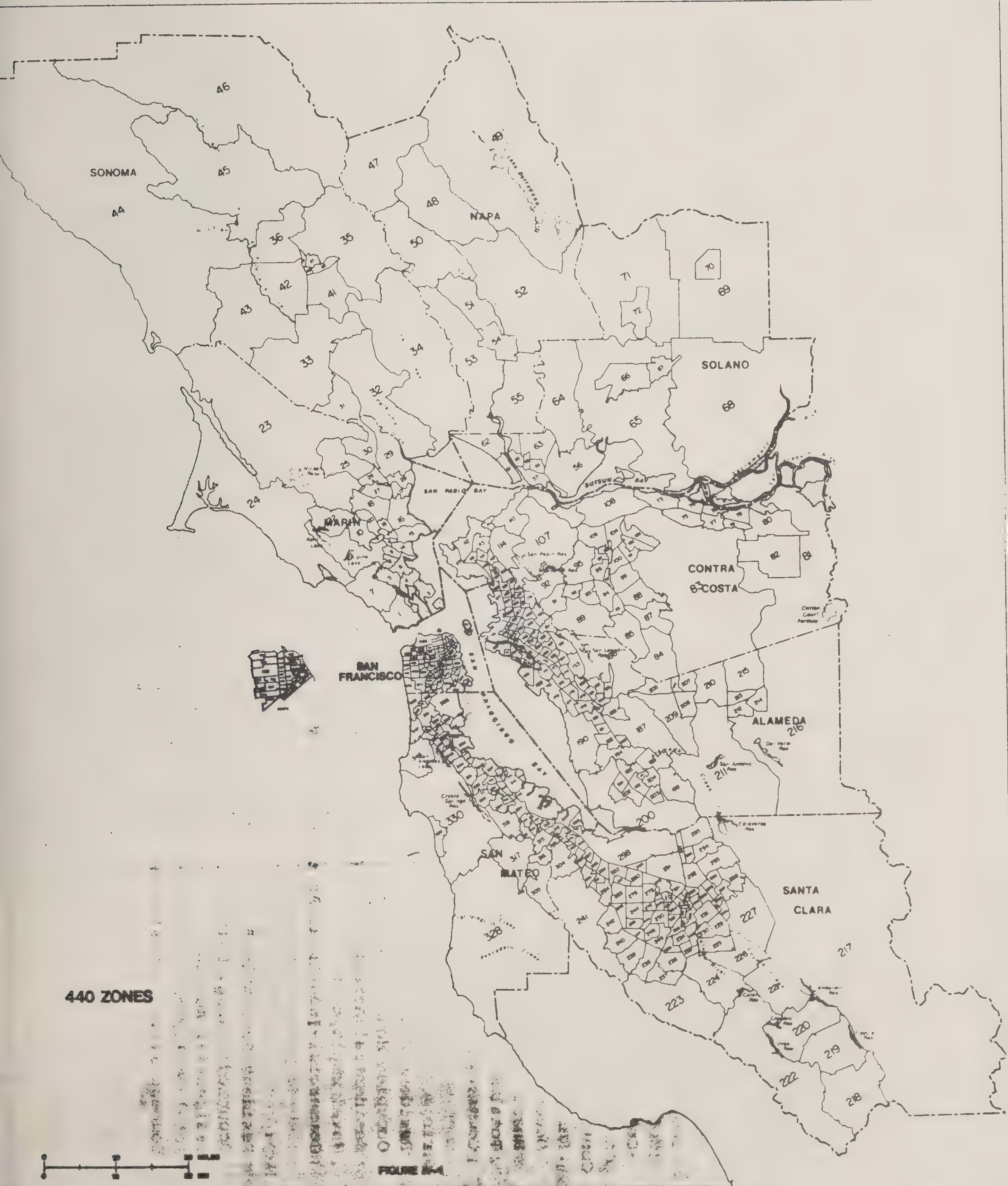


FIGURE [illegible]

Source: Metropolitan Transportation Commission, [illegible].

TABLE IV-1

SUMMARY OF BASE CASE 1 DATA FROM
PROVISIONAL SERIES 3 PROJECTIONS

County/Parameter	1975	1980	1985	1990	1995	2000
Alameda						
Resident Population[a]	1,057,823	1,105,293	1,152,788	1,199,185	1,212,515	1,233,862
Occupied Housing Units	396,618	440,005	479,390	515,173	529,572	544,204
Residential Acreage	42,639	50,529	59,092	64,135	64,025	63,910
Total Employment	434,270	464,764	487,561	511,469	529,731	546,385
Commercial-Industrial Acreage	23,043	24,801	25,753	26,843	27,353	27,596
Contra Costa						
Resident Population[a]	560,690	609,828	667,148	723,575	756,891	783,142
Occupied Housing Units	201,728	236,813	273,531	308,211	326,587	341,748
Residential Acreage	32,342	44,905	60,390	73,979	79,074	82,979
Total Employment	160,057	172,598	188,640	204,341	226,632	236,875
Commercial-Industrial Acreage	18,168	18,480	19,200	20,291	21,994	22,424
Marin						
Resident Population[a]	210,466	222,860	234,668	262,764	285,912	295,604
Occupied Housing Units	79,181	90,235	99,868	117,574	129,360	134,823
Residential Acreage	17,087	24,283	33,489	44,190	47,637	48,362
Total Employment	55,728	59,736	62,485	65,298	67,388	68,791
Commercial-Industrial Acreage	3,497	3,663	3,767	3,893	3,993	4,052
Napa						
Resident Population[a]	83,274	83,728	83,650	85,432	90,812	105,634
Occupied Housing Units	28,356	29,835	30,861	32,392	34,794	42,154
Residential Acreage	6,807	7,403	7,854	8,348	9,070	12,186
Total Employment	28,630	31,768	33,843	36,078	39,153	41,858
Commercial-Industrial Acreage	2,669	2,960	3,196	3,444	3,758	4,018

TABLE IV-1
(Continued)

SUMMARY OF BASE CASE 1 DATA FROM
PROVISIONAL SERIES 3 PROJECTIONS

County/Parameter	1975	1980	1985	1990	1995	2000
San Francisco						
Resident Population[a]	647,952	642,062	626,254	619,374	618,346	622,009
Occupied Housing Units	299,343	307,187	307,657	310,946	314,405	317,901
Residential Acreage	9,582	9,699	9,703	9,693	9,685	9,676
Total Employment	495,406	532,015	565,666	599,188	618,763	639,623
Commercial-Industrial Acreage	6,744	6,766	6,830	6,869	6,888	6,892
San Mateo						
Resident Population[a]	569,533	583,658	605,724	624,434	621,054	623,152
Occupied Housing Units	208,144	224,271	242,069	258,150	260,348	262,630
Residential Acreage	32,622	38,500	52,948	61,955	61,938	61,921
Total Employment	225,130	231,281	243,946	255,975	264,731	272,580
Commercial-Industrial Acreage	11,724	12,108	12,562	13,144	13,227	13,285
Santa Clara						
Resident Population[a]	1,144,324	1,218,225	1,327,930	1,415,175	1,511,187	1,615,550
Occupied Housing Units	392,401	448,981	517,472	572,381	620,838	679,717
Residential Acreage	53,346	66,123	101,799	111,501	123,179	138,358
Total Employment	517,750	570,831	651,977	724,028	786,724	834,632
Commercial-Industrial Acreage	26,964	29,971	33,048	35,478	37,122	38,209
Solano						
Resident Population[a]	175,958	196,064	212,694	235,295	296,491	340,532
Occupied Housing Units	62,288	76,078	87,858	102,657	132,889	156,762
Residential Acreage	8,804	13,635	18,161	23,383	31,658	37,089
Total Employment	52,293	59,142	64,230	69,744	77,100	83,329
Commercial-Industrial Acreage	5,860	6,907	7,457	8,097	8,907	9,622

TABLE IV-1
(Continued)

SUMMARY OF BASE CASE 1 DATA FROM
PROVISIONAL SERIES 3 PROJECTIONS

County/Parameter	1975	1980	1985	1990	1995	2000
Sonoma						
Resident Population[a]	238,108	266,531	283,187	298,771	327,998	352,018
Occupied Housing Units	100,529	120,595	133,894	146,417	162,907	177,861
Residential Acreage	18,011	26,618	33,108	39,535	47,411	52,932
Total Employment	77,294	92,757	103,372	114,509	127,013	138,633
Commercial-Industrial Acreage	6,763	7,834	8,512	9,224	9,948	10,578
Bay Region						
Resident Population[a]	4,688,128	4,928,249	5,194,043	5,464,005	5,721,206	5,971,503
Occupied Housing Units	1,768,588	1,974,000	2,172,600	2,363,901	2,511,700	2,657,800
Residential Acreage	221,240	281,695	376,544	436,719	473,677	507,413
Total Employment	2,046,558	2,214,892	2,401,720	2,580,630	2,737,235	2,862,706
Commercial-Industrial Acreage	105,432	113,490	120,325	127,283	133,190	136,676

[a]Group Quarters population is not included in this total; this group was assumed to be included in commercial water-use category.

WATER-USE PROJECTIONS METHODOLOGY

Municipally-supplied water use was projected from a 1975 base, which was established on the basis of information on water demand obtained from 45 water distribution agencies in the Bay Area. Unit water-use factors for different water-use categories, as a function of density, were determined from detailed information on water demand provided by the East Bay Municipal Utility District (EBMUD) for 102 of the 440 zones in the Bay Area. These factors, after adjustment to other areas in the nine-county region, were applied to the ABAG Provisional Series 3 Projections to obtain the projected water use by category at five-year increments through the period to year 2000.

Future agricultural water requirements for crop irrigation were estimated by projecting the total crop acreage by county, estimating the percentage of crop acreage subject to irrigation, and applying water application rates for specific crop categories.

Water-Use Categories

The following water-use categories were used to provide the best possible accuracy and reliability in the projections given the information and data available:

1. Inside residential use
2. Outside residential use
3. Commercial-industrial use
4. Public authority use
5. Unaccounted-for use
6. Agricultural irrigation use

The first five use categories constitute municipally-supplied water; the last category constitutes agricultural irrigation water.

Municipally-Supplied Water

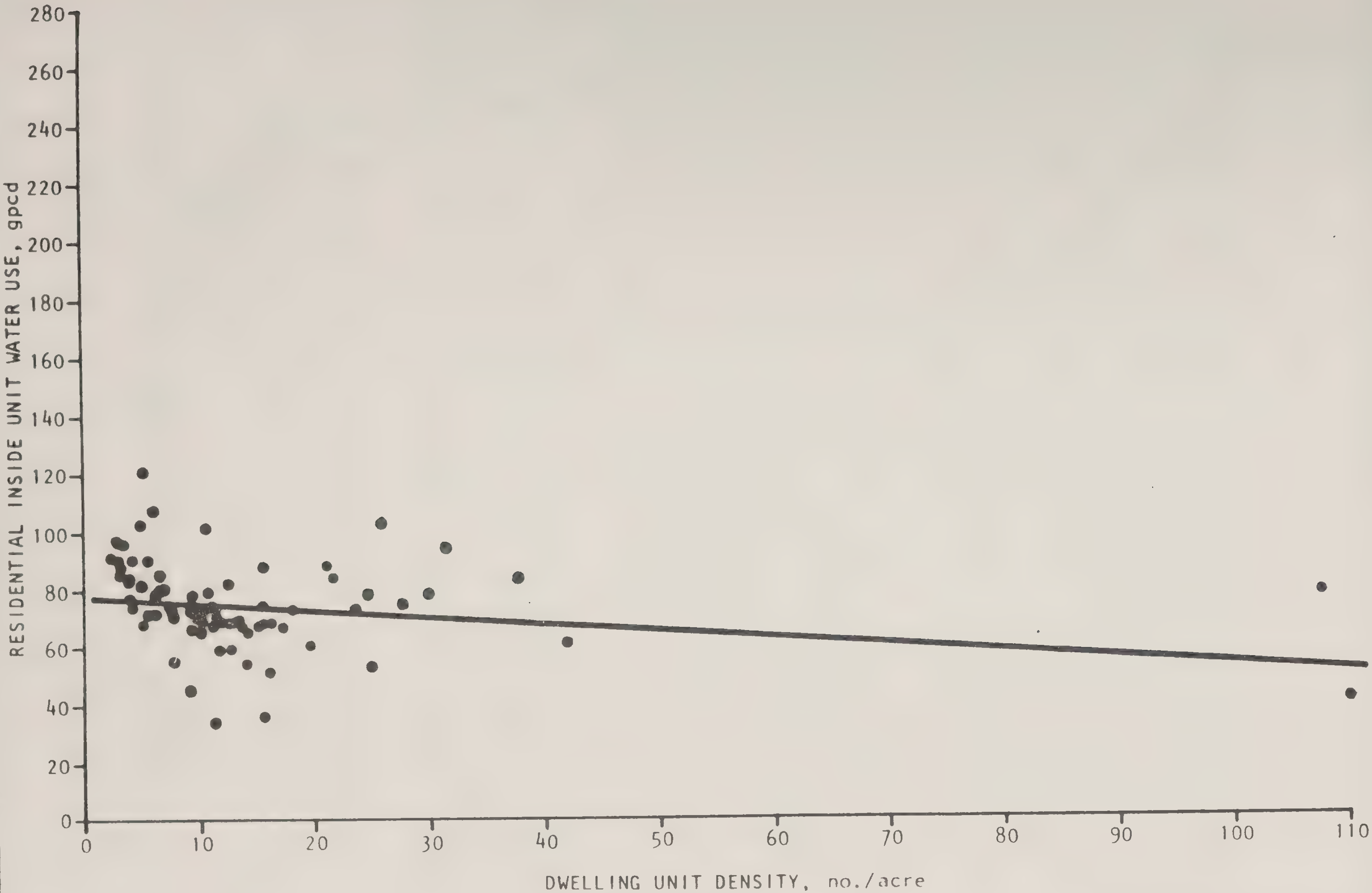
Detailed data on residential and commercial-industrial water use in 1975 were obtained from EBMUD for their 102 zones within the total 440-zone coverage of the nine-county Bay Area. These data are representative of most areas or conditions encountered in the Bay Area, ranging from high density areas in Alameda County to

low density areas in Contra Costa County. Using these water-use data and the 1975 population, housing, employment, and land-use data from ABAG, a set of relationships between existing unit water use and residential or commercial-industrial employee density was developed.

Residential water use was separated into inside use and outside use for two reasons. First, the ABAG Provisional Series 3 Projections indicated a continuing decline in average household size throughout the period from 2.65 in 1975 to 2.25 in 2000 for Base Case 1. The projected decline for Base Case 2 is greater, decreasing to 2.10 by 2000. Because outside residential water use consists primarily of landscape irrigation, the amount of which is independent of the number of residents living in the dwelling unit, application of the conventional overall factor based on per capita water use would produce unrealistically low total water-use requirements. Secondly, water conservation measures, as described in Chapter III, provide for different savings with respect to inside and outside residential use.

Inside residential unit water use, expressed as gallons per capita per day (gpcd) was plotted against residential dwelling unit density, expressed as number of occupied dwelling units per net residential acreage (no./acre). This relationship, shown on Figure IV-2, was derived from February 1975 water-use data provided by EBMUD that is considered to be representative of inside residential water use because of the large amount of rainfall that occurred that month. The relationship indicates that at a low dwelling unit density of two residential units per acre, the inside unit water use is 78 gpcd; at a high dwelling unit density of 110 residential units per acre, the inside unit water use decreases to 50 gpcd.

Outside residential unit water use, expressed as gallons per dwelling unit per day (gpdud), versus residential dwelling unit density, expressed as number of occupied dwelling units per net residential acreage (no./acre), is shown on Figure IV-3. This curve was derived by subtracting inside unit water use from total residential unit water use (in 1975) for each EBMUD 440 zone and relating this consumption to dwelling unit density. This relationship shows a dramatic decrease in outside residential unit water use from over 300 gpdud at typical single-family residential densities to under 10 gpdud for high residential densities associated with apartments.



INSIDE RESIDENTIAL
UNIT WATER USE RELATIONSHIP

FIGURE IV-2

JBGA/DLF/RTC 4/77

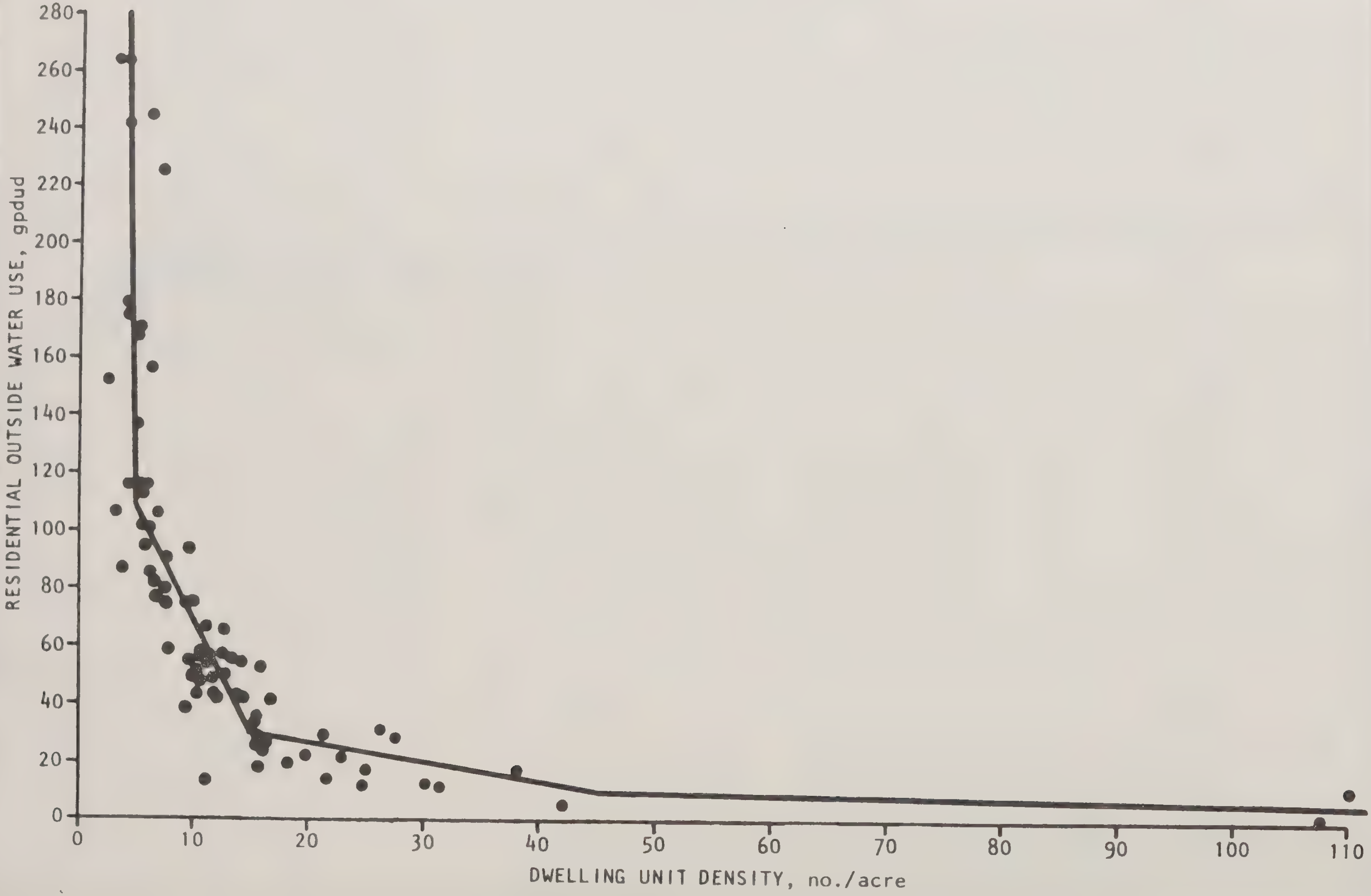


FIGURE IV-3

OUTSIDE RESIDENTIAL UNIT WATER USE RELATIONSHIP

JBGA/DLF/RTC 4/77

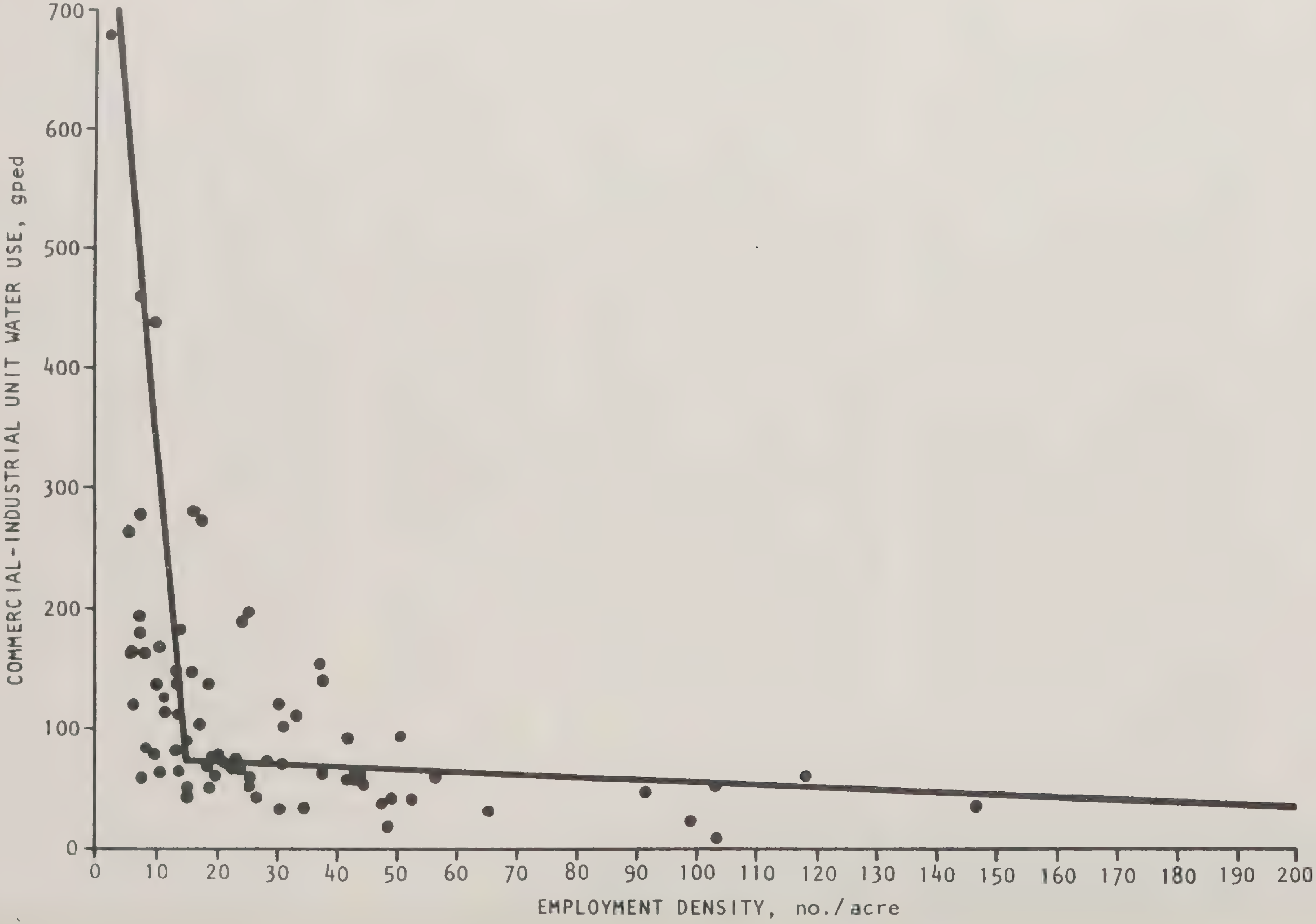
Combined commercial and industrial water use, expressed as gallons per employee per day (gped), as a function of employee density, defined as number of employees per net commercial and industrial acreage (no./acre), was determined from EBMUD's 1975 water-use data, and is presented on Figure IV-4. Oil refineries in the area use large quantities of water and were treated as a special case. This category excludes self-supplied cooling water taken from San Francisco Bay and used by a number of industrial plants and power plants in the Bay Area. The relationship indicates a sharp decline in commercial-industrial unit water use from over 700 gped at an employee density of 2 or 3/acre to about 70 gped at 15/acre, and a gradual decline thereafter to about 40 gped at an employee density of 150/acre.

To apply these relationships throughout the Bay Area, actual water-use data for 1975 were obtained from 45 water distribution agencies in the Bay Area. The curves were then adjusted for each of the remaining 440 zones outside the EBMUD service area using these data. Factors used to adjust the relationships generally varied within plus or minus 40 percent for residential water use and plus or minus 70 percent for commercial-industrial water use. Water-use data for 1975 obtained in this study have been listed in Table II-2. The 45 agencies supplied approximately 85 percent of all municipal-industrial water used in the Bay Area. For 440 zones outside of the service area of these 45 agencies, the factors from the nearest water distribution agency were used to adjust the general relationships.

Public authority water use was determined based on a percentage of the subtotal of residential and commercial-industrial water use in each 440 zone. Percentages were derived from actual data provided by water distribution agencies. For zones where no data were available, percentages applicable to nearby water distribution agencies were used. Percentages generally ranged from one to 18 percent.

Unaccounted-for water includes unmetered water from fire hydrants and water losses in the distribution system. This use was determined as a percentage of the subtotal of residential, commercial-industrial, and public authority water use and was based on actual data where available. Percentages in this category ranged from three to 11 percent.

Municipally-supplied water-use projections for five-year increments to the year 2000 were made by applying these relationships to the population, housing, employment, and



COMMERCIAL-INDUSTRIAL
UNIT WATER USE RELATIONSHIP
JBGA/DLF/RTC 4/77

FIGURE IV-

TABLE IV-2

CURRENT (1975) RESIDENTIAL AND COMMERCIAL-INDUSTRIAL WATER USE

County	Water Use, mgd					
	Inside Residential	Outside Residential	Commercial-Industrial	Public Authority	Unaccounted-for	Total
Alameda	81.251	29.952	61.616	7.172	15.677	195.669
Contra Costa	43.905	25.372	66.739	5.540	10.365	151.920
Marin	14.606	12.452	4.085	1.984	3.393	36.521
Napa	5.070	4.341	4.723	1.047	1.654	16.836
San Francisco	30.802	3.793	50.226	9.050	5.069	98.941
San Mateo	43.812	21.813	24.646	4.356	2.997	97.624
Santa Clara	99.056	42.459	77.627	23.732	16.876	259.749
Solano	13.701	6.528	13.854	6.336	2.065	42.484
Sonoma	13.768	8.495	8.327	1.952	2.081	34.623
Bay Region	345.971	155.206	311.843	61.169	60.176	934.366

land-use projections developed by ABAG. Future water use was estimated on an incremental basis by obtaining the predicted increase in population, dwelling units, employment, and acreage that would occur over each succeeding five-year increment, determining the appropriate density units for this increment, calculating the corresponding unit water use, and adding this use to the total for the preceding five-year increment. This procedure assumes that existing or developed areas would not change once they exist. It was assumed that unit water-use factors for residential and commercial-industrial water use and percentages for public authority and unaccounted-for water use derived from the 1975 data would remain constant throughout the planning period.

Projections were performed by computer for each 440 zone and for each water-use category in five-year increments to the year 2000.

The projection procedure was applied to the 1975 ABAG data base and produced the results by county shown in Table IV-2.

Agricultural Irrigation

Current (1975) agricultural irrigation water use in the nine-county Bay Area was determined by reconciling irrigated crop acreage in each county (obtained from each County Agricultural Commissioner) and water application rates [Reference 28] with information provided by water distribution agencies and other knowledgeable individuals on actual quantities of water supplied and actual water application rates.

A tabulation of the estimated percentage of the total acreage irrigated, the acreage irrigated, and the appropriate water application rates, by crop, is provided in Table IV-3 for each county. Current agricultural water use by county is presented in Table IV-4.

Projections of future irrigated acreage in the Bay Area through year 2000 were made by considering historical trends, projected population growth, projected increases in land area devoted to urban activities, and market factors. Historical trends in total crop acreage by county are presented in Table IV-5.

The following assumptions were made in developing the projected total crop acreages:

TABLE IV-3

PERCENTAGE OF TOTAL CROP ACREAGE IRRIGATED, IRRIGATED CROP ACREAGE, AND WATER APPLICATION RATES

County	Field Crops	Vege-tables	Fruits & Nuts	Vine-yards	Horti-cultural	Irrigated Pasture
Alameda	7[a] 2,029[b] 3.0[c]	50 2,207 2.9	100 978 1.5	100 1,757 0.9	100 520 4.4	100 910 3.0
Contra Costa	48 13,334 3.4	100 8,480 2.9	100 12,157 2.0	100 1,051 1.7	100 167 3.9	100 5,600 4.5
Marin	4 184 1.7	100 → Included	100 30 2.0	100 ← Included	100 150 1.7	100 530 3.4
Napa	14 1,170 1.7	100 2,786 1.7	25 800 2.0	50 7,862 1.5	100 - 1.7	100 400 3.4
San Francisco[d]						
San Mateo	0 0 -	100 3,587 1.1	0 0 -	0 0 -	100 1,255 2.5	100 542 2.0
Santa Clara	60 8,640 3.0	100 15,617 2.9	100 20,756 1.5	100 2,334 0.9	100 438 4.4	100 1,500 3.0
Solano	58 70,166 2.5	100 22,991 2.4	85 14,635 2.4	40 659 2.2	100 2,162 2.4	100 25,800 4.1
Sonoma	4 1,011 2.0	42 101 1.7	36 5,995 2.0	100 16,176 1.3	100 16 1.7	100 9,000 3.4

[a] Percentage of total crop acreage irrigated, %
[b] Acreage of irrigated crop, acre
[c] Water application rate, ft/yr
[d] All values are zero

TABLE IV-4

CURRENT (1975) AGRICULTURAL WATER USE

County	Water Use, acre-ft/yr
Alameda	20,000
Contra Costa	121,900
Marin	2,400
Napa	21,500
San Francisco	0
San Mateo	8,200
Santa Clara	110,900
Solano	371,200
Sonoma	65,800
Bay Region	722,500

Vegetables. Total vegetable crop acreage in the Bay Area will increase in direct proportion to population growth. A decline in vegetable acreage in some counties will be offset by growth in other, less urbanized counties.

Vineyard. Indications are that grapes have been overplanted, but vineyard acreage is still expected to increase slowly through the year 2000.

Fruits and Nuts. This crop has experienced dramatic reductions in acreage due to higher production costs and urban development. Further reductions in fruit and nut acreage are anticipated.

Horticulture. This is a profitable crop and recent upward trends are expected to continue.

Irrigated Pasture. A continuing decline in irrigated pasture acreage is expected, except in Sonoma County where reclaimed wastewater will be available.

Field Crops. Future field crop acreage was in part based upon the relation between the changes in acreage of the other five categories and the total acreage required for new urban

TABLE IV-5

HISTORICAL TOTAL CROP ACREAGE

County	Year	Field Crops	Vegetables	Fruits & Nuts	Vineyards	Horticultural	Irrigated Pasture	Total
Alameda	1958	41,689	13,047	4,103	2,438	224	3,121	64,622
	60	39,857	14,569	4,139	2,438	600	2,441	64,044
	66	22,658	11,184	2,916	1,800	824	1,640	41,022
	70	19,895	7,533	1,598	1,750	352	1,200	32,328
	75	28,980	4,414	978	1,757	520	910	37,559
Contra Costa	1958	36,603	16,886	29,799	2,464	-	-	-
	60	38,449	16,936	25,787	1,720	92	7,000	89,974
	66	37,391	12,442	19,653	1,442	91	7,500	78,519
	70	31,210	7,230	17,725	1,218	25	7,060	64,468
	75	27,780	8,480	12,157	1,051	167	5,600	55,235
Marin	1955	4,792	113	129	48	27	-	-
	60	5,944	20	95		54	750	6,863
	66	3,500	20	55		66	800	4,441
	70	5,000		90		145	800	6,035
	75	4,600	Included →	30	← Included	150	530	5,310
Napa	1960	6,503	300	13,163	9,623	300	2,500	32,389
	66	5,226	230	7,761	11,381	500	2,150	27,248
	70	5,375	-	6,015	12,254	-	1,500	-
	75	8,358	2,786	3,200	15,725	-	400	-
San Francisco				ALL VALUES ZERO				

TABLE IV-5
(Continued)

HISTORICAL TOTAL CROP ACREAGE

County	Year	Field Crops	Vege-tables	Fruits & Nuts	Vine-yards	Horti-cultural	Irrigated Pasture	Total
San Mateo	1957	23,398	5,968	379	18	1,146	-	-
	60	17,932	4,653	343	7	1,021	1,211	25,167
	66	8,220	3,306	157	-	888	660	-
	70	4,879	3,326	151	14	1,216	647	10,219
	75	5,602	3,587	213	20	1,255	542	11,199
Santa Clara	1950	16,862	26,277	80,865	5,150	631	-	-
	60	17,900	14,220	62,700	3,752	653	4,200	103,425
	66	17,535	15,632	47,583	3,145	730	1,800	86,425
	70	13,534	15,615	36,011	2,603	467	1,400	69,630
	75	14,400	15,617	20,756	2,334	438	1,500	55,045
Solano	1957	127,979	20,066	17,341	636	1,706	-	-
	60	118,305	14,748	17,254	593	-	19,000	-
	66	118,445	12,153	15,825	635	-	23,500	-
	70	127,930	13,907	19,381	790	3,110	24,500	189,618
	75	120,976	22,991	17,218	1,647	2,162	25,800	190,794
Sonoma	1958	38,755	1,121	27,348	11,262	-	15,000	-
	60	45,423	436	26,342	10,700	111	15,000	98,012
	66	36,760	370	28,294	11,600	24	15,000	92,048
	70	28,270	260	27,831	12,597	31	15,000	83,989
	75	25,275	240	16,424	16,176	16	9,000	67,131

development. Where acreage in field crops would be insufficient to balance urban growth requirements, urban growth could be accommodated elsewhere.

Projections of future agricultural irrigation water use were made using the total crop acreage projections shown in Table IV-6 and assuming that the percentage of each crop irrigated and the water application rates, presented in Table IV-3, will remain the same throughout the planning period.

WATER-USE PROJECTIONS

Municipal Water Use

Projected total residential and commercial-industrial, i.e., municipal, water use by county in the nine-county Bay Area with no water conservation is presented in Table IV-7 for five-year increments through the year 2000. Also shown are the incremental increases of water use for each five-year period.

In Alameda County, the projections indicate an increase of from seven to over eight percent in municipal water use through 1990, declining to about one percent thereafter until 2000. Over the total period from 1975 to 2000, an increase in municipal water use of 28.1 percent is indicated, increasing from 195.7 mgd in 1975 to 250.6 mgd in 2000.

Projected municipal water use in Contra Costa County increases at an increasing rate to 13.5 percent in 1985, maintains this rate of increase until 1990, and then decreases to an incremental increase of 5.2 percent by 2000. An overall increase of 59.7 percent through the 25-year period is projected, increasing from 151.9 mgd in 1975 to 242.6 in 2000.

Marin County will experience a sharp increase of 16.6 percent in municipal water use during the period from 1975 to 1980, a lesser increase of 13.4 percent during the next five-year period, and the greatest incremental increase of 22.2 percent in the period from 1985 to 1990. A decrease in incremental water use is indicated thereafter, decreasing to 2.0 percent in the period from 1995 to 2000. Over the period from 1975 to 2000, an overall increase of 81.3 percent in municipal water use is projected, rising from 36.5 in 1975 to 66.2 mgd in 2000.

TABLE IV-6

PROJECTED TOTAL CROP ACREAGE

County	Year	Field Crops	Vege-tables	Fruits & Nuts	Vine-yards	Horti-cultural	Irrigated Pasture	Total
Alameda	1980	24,600	4,000	700	1,800	500	800	32,400
	85	19,600	3,500	600	1,800	500	600	26,600
	90	15,100	3,000	400	1,800	500	500	21,300
	95	10,500	2,500	200	1,800	500	400	15,900
	2000	6,000	2,000	0	1,800	500	300	10,600
Contra Costa	1980	25,800	8,800	11,700	1,000	100	5,100	52,500
	85	23,900	9,200	11,300	1,000	100	4,600	50,100
	90	21,900	9,600	10,900	1,000	100	4,100	47,600
	95	20,000	10,000	10,500	1,000	100	3,600	45,200
	2000	18,000	10,400	10,000	1,000	100	3,100	42,600
Marin	1980	4,300		100		100	400	4,900
	85	3,800		100		100	300	4,300
	90	3,600		100		100	300	4,100
	95	3,300	→	100	←	100	200	3,700
	2000	3,000	Included	100	Included	100	100	3,300
Napa	1980	6,800	2,900	2,700	15,700	600	300	29,000
	85	5,500	3,000	2,300	15,700	600	200	27,300
	90	4,100	3,200	1,900	15,700	600	200	25,700
	95	2,800	3,300	1,400	15,700	700	100	24,000
	2000	1,500	3,500	1,000	15,700	700	0	22,400
San Francisco				ALL VALUES ZERO				

TABLE IV-6
(Continued)

PROJECTED TOTAL CROP ACREAGE

County	Year	Field Crops	Vege-tables	Fruits & Nuts	Vine-yards	Horti-cultural	Irrigated Pasture	Total
San Mateo	1980	4,800	3,800	200	0	1,400	400	10,600
	85	4,200	4,100	200	0	1,400	400	10,300
	90	3,400	4,400	200	0	1,400	300	9,700
	95	2,800	4,700	200	0	1,500	200	9,400
	2000	2,000	5,000	200	0	1,500	200	8,900
Santa Clara	1980	12,500	14,700	17,500	2,700	1,000	1,400	49,800
	85	10,700	14,000	14,400	3,200	1,200	1,200	44,700
	90	8,800	13,400	11,300	3,800	1,600	1,000	39,900
	95	7,000	12,700	8,200	4,300	1,900	900	35,000
	2000	5,000	12,000	5,000	5,000	2,300	800	30,100
Solano	1980	110,000	26,200	17,300	3,000	2,500	26,200	185,200
	85	100,000	29,000	17,300	4,700	3,200	27,200	181,400
	90	90,000	32,200	17,300	6,500	4,000	28,000	178,000
	95	80,000	35,000	17,300	8,000	4,400	29,000	173,700
	2000	70,000	37,000	17,300	9,800	5,000	30,000	169,100
Sonoma	1980	24,200	300	14,300	16,000	100	8,200	63,100
	85	23,200	500	12,200	16,000	200	7,500	59,600
	90	22,200	600	10,100	16,000	300	6,600	55,800
	95	21,200	800	8,000	16,000	400	5,800	52,200
	2000	20,000	1,000	5,900	16,000	500	5,000	48,400
Bay Region	1980	213,000	60,700	64,500	40,200	6,300	42,800	427,500
	85	190,900	63,300	58,400	42,400	7,300	42,000	404,300
	90	169,100	66,400	52,200	44,800	8,600	41,000	382,100
	95	147,600	69,000	45,900	46,800	9,600	40,200	359,100
	2000	125,500	70,900	39,500	49,300	10,700	39,500	335,400

TABLE IV-7

PROJECTED TOTAL RESIDENTIAL AND COMMERCIAL-INDUSTRIAL WATER USE[a]
(ABAG Base Case 1 Projections)

County	1980		1985		1990		1995		2000	
	mgd	Δ%[b]	mgd	Δ%	mgd	Δ%	mgd	Δ%	mgd	Δ%
Alameda	209.2	6.9	226.4	8.2	245.2	8.3	248.0	1.1	250.6	1.0
Contra Costa	165.7	9.1	188.0	13.5	213.3	13.5	230.7	8.2	242.6	5.2
Marin	42.6	16.6	48.3	13.4	59.0	22.2	64.9	10.0	66.2	2.0
Napa	17.6	4.5	18.4	4.5	19.5	6.0	21.1	8.2	25.1	19.0
San Francisco	99.5	0.6	99.8	0.3	100.0	0.2	100.4	0.4	100.9	0.5
San Mateo	102.8	5.3	111.3	8.3	117.5	5.6	117.5	0.0	117.8	0.3
Santa Clara	287.8	10.8	332.2	15.4	360.3	8.5	386.1	7.2	412.9	6.9
Solano	53.6	26.1	64.0	19.4	77.3	20.8	101.3	31.0	113.3	11.8
Sonoma	45.7	32.1	53.2	16.4	59.9	12.6	68.3	14.0	74.9	9.7
Bay Region	1,024.5	9.7	1,141.6	11.4	1,252.0	9.7	1,338.3	6.9	1,404.3	4.9

[a]No water conservation

[b]Increase over preceding five-year increment

In Napa County, the projected incremental increase in municipal water use is moderate during the first 10 years (4.5 percent), and then escalates to 19.0 percent during the period from 1995 to 2000. The overall increase in municipal water use in Napa County over the 25-year planning period is 49.1 percent, increasing from 16.8 mgd in 1975 to 25.1 in 2000.

Projected municipal water use in San Francisco County over the 25-year period increases only slightly (2.0 percent), from 98.9 mgd in 1975 to 100.9 mgd in 2000.

The greatest incremental increase in municipal water use in San Mateo County will occur in the period from 1980 to 1985 (8.3 percent). The overall increase in municipal water use in San Mateo County will be 20.7 percent, increasing from 97.6 mgd in 1975 to 117.8 mgd in 2000.

Santa Clara County likewise will experience its greatest incremental municipal water-use increase in the period from 1980 to 1985 (15.4 percent). Projections indicate that the overall increase in municipal water use over the 25-year period will be 59.0 percent, increasing from 259.7 mgd in 1975 to 412.9 mgd in 2000.

The projections for Solano County indicate the greatest increase in the Bay Area for municipal water use (166.6 percent), increasing from 42.5 mgd in 1975 to 113.3 mgd in 2000. The largest five-year incremental increase (31.0 percent) will occur in the period from 1990 to 1995.

Sonoma County will also experience a large increase in municipal water use during the next 25 years. An overall increase of 116.5 percent will occur, increasing from 34.6 mgd in 1975 to 74.9 mgd in 2000. The greatest incremental increase (32.1 percent) is projected for the period 1975 to 1980.

For the nine-county Bay Area as a whole, a 50.3 percent increase in municipal water use is projected over the 25-year period, increasing from 934.4 mgd in 1975 to 1,404.3 mgd in 2000. The greatest incremental increase for the Bay Area (11.4 percent) will occur in the period from 1980 to 1985.

Implementation of the water conservation measures described in Chapter III would result in decreased municipal water use. Projections of municipal water use for each of the eight water conservation alternatives (see Table III-12) by county are presented in Table IV-8.

TABLE IV-8

PROJECTED TOTAL RESIDENTIAL AND COMMERCIAL-INDUSTRIAL WATER USE WITH IMPLEMENTATION OF WATER CONSERVATION ALTERNATIVES*
(mgd)

County/Alternative	1980	1985	1990	1995	2000
Alameda					
Alternative 1	205.8	220.9	237.9	239.7	240.9
Alternative 2	194.9	209.3	225.4	227.1	228.2
Alternative 3	184.7	198.2	213.5	215.1	216.2
Alternative 4	153.9	165.2	178.0	179.3	180.2
Alternative 5	119.9	128.1	137.4	138.7	139.4
Alternative 6	201.4	215.4	231.3	233.0	234.1
Alternative 7	191.3	204.6	219.8	221.3	222.4
Alternative 8	181.2	193.9	208.2	209.7	210.7
Contra Costa					
Alternative 1	163.6	184.1	207.7	223.6	234.2
Alternative 2	155.0	174.4	196.8	211.9	222.0
Alternative 3	146.8	165.3	186.5	200.8	210.3
Alternative 4	122.4	137.7	155.4	167.3	175.3
Alternative 5	98.8	109.8	123.2	133.2	139.5
Alternative 6	160.5	179.4	201.5	216.7	226.7
Alternative 7	152.4	170.4	191.4	205.9	215.3
Alternative 8	144.4	161.5	181.4	195.1	204.0
Marin					
Alternative 1	42.0	47.2	57.1	62.2	63.0
Alternative 2	39.7	44.6	54.0	58.9	59.6
Alternative 3	37.6	42.3	51.1	55.8	56.5
Alternative 4	31.3	35.2	42.6	46.5	47.0
Alternative 5	22.1	24.7	29.7	32.3	32.7
Alternative 6	40.8	45.6	54.6	59.2	59.9
Alternative 7	38.8	43.3	51.8	56.2	56.9
Alternative 8	36.7	41.0	49.1	53.3	53.9
Napa					
Alternative 1	17.4	18.1	19.0	20.4	24.0
Alternative 2	16.4	17.1	18.0	19.3	22.7
Alternative 3	15.6	16.2	17.0	18.3	21.5
Alternative 4	13.0	13.5	14.2	15.2	17.9
Alternative 5	10.1	10.6	11.2	12.1	14.0
Alternative 6	17.0	17.7	18.6	19.9	23.2
Alternative 7	16.2	16.8	17.7	18.9	22.0
Alternative 8	15.3	15.9	16.7	17.9	20.9

TABLE IV-8
(Continued)

PROJECTED TOTAL RESIDENTIAL AND COMMERCIAL-INDUSTRIAL WATER USE WITH IMPLEMENTATION OF WATER CONSERVATION ALTERNATIVES*
(mgd)

County/Alternative	1980	1985	1990	1995	2000
San Francisco					
Alternative 1	98.4	98.5	98.6	98.6	98.8
Alternative 2	93.0	93.1	93.2	93.2	93.4
Alternative 3	88.1	88.2	88.3	88.3	88.5
Alternative 4	73.4	73.5	73.6	73.6	73.8
Alternative 5	62.4	62.7	62.9	63.0	63.1
Alternative 6	96.1	96.2	96.4	96.4	96.6
Alternative 7	91.3	91.4	91.5	91.6	91.8
Alternative 8	86.5	86.6	86.7	86.8	87.0
San Mateo					
Alternative 1	101.5	109.4	115.1	115.1	115.3
Alternative 2	96.3	103.8	109.2	109.2	109.4
Alternative 3	91.2	98.4	103.5	103.4	103.6
Alternative 4	76.0	82.0	86.2	86.2	86.4
Alternative 5	57.2	61.4	64.7	64.7	64.9
Alternative 6	99.6	106.9	112.2	112.1	112.3
Alternative 7	94.6	101.6	106.6	106.5	106.7
Alternative 8	89.6	96.2	101.0	100.9	101.1
Santa Clara					
Alternative 1	285.0	326.1	351.0	373.3	396.4
Alternative 2	269.0	307.9	331.5	352.7	374.6
Alternative 3	255.0	291.8	314.1	334.2	354.9
Alternative 4	212.8	243.4	262.1	278.8	296.1
Alternative 5	166.3	189.8	204.5	217.0	229.3
Alternative 6	278.9	317.7	341.3	362.3	383.7
Alternative 7	265.1	301.9	324.3	344.3	364.6
Alternative 8	251.2	286.1	307.4	326.2	345.5

TABLE IV-8
(Continued)

PROJECTED TOTAL RESIDENTIAL AND COMMERCIAL-INDUSTRIAL WATER USE WITH IMPLEMENTATION OF WATER CONSERVATION ALTERNATIVES*
(mgd)

County/Alternative	1980	1985	1990	1995	2000
Solano					
Alternative 1	53.2	63.1	75.7	98.3	109.1
Alternative 2	50.0	59.4	71.3	92.5	102.8
Alternative 3	47.4	56.3	67.6	87.6	97.4
Alternative 4	39.5	46.9	56.3	73.0	81.1
Alternative 5	30.9	36.7	44.0	56.2	62.5
Alternative 6	51.7	61.2	73.1	94.2	104.4
Alternative 7	49.1	58.1	69.5	89.4	99.2
Alternative 8	46.5	55.1	65.8	84.7	93.9
Sonoma					
Alternative 1	44.8	51.7	58.0	65.6	71.5
Alternative 2	42.4	48.9	54.8	62.1	67.7
Alternative 3	40.1	46.4	52.0	58.8	64.1
Alternative 4	33.4	38.6	43.3	49.0	53.4
Alternative 5	24.7	28.3	31.6	35.6	38.7
Alternative 6	43.5	50.0	55.7	62.8	68.2
Alternative 7	41.3	47.5	53.0	59.7	64.8
Alternative 8	39.1	45.0	50.2	56.5	61.4
Bay Region					
Alternative 1	1,011.7	1,119.2	1,220.1	1,296.8	1,353.0
Alternative 2	956.7	1,058.6	1,154.2	1,226.8	1,280.3
Alternative 3	906.5	1,002.9	1,093.6	1,162.4	1,213.0
Alternative 4	755.7	836.1	911.6	968.9	1,011.1
Alternative 5	592.4	652.2	709.2	752.7	784.2
Alternative 6	989.5	1,090.1	1,184.7	1,256.7	1,309.2
Alternative 7	940.1	1,035.7	1,125.6	1,193.9	1,243.8
Alternative 8	890.7	981.3	1,066.4	1,131.2	1,178.4

*ABAG Base Case 1 Projections

For the entire nine-county Bay Area, the municipal water use savings that could be realized by implementation of each of the water conservation alternatives over the 25-year planning period are presented in Table IV-9. Generally, these water savings are higher in the counties that are expected to experience greater growth, i.e., Marin, Napa, Solano, and Sonoma counties, where there are more opportunities to implement water conservation in new construction.

TABLE IV-9

PROJECTED SAVINGS IN BAY AREA MUNICIPAL WATER USE FOR WATER CONSERVATION ALTERNATIVES (1975-2000)

Alternative	Reduction in Use %
1	3.7
2	8.8
3	13.6
4	28.0
5	44.2
6	6.8
7	11.4
8	16.1

The increases in each category of municipal water use projected to occur between 1975 and 2000, by county, with no water conservation and with a reasonable maximum level of water conservation, are presented in Table IV-10. Although inside residential water use increases generally in direct proportion to population growth, outside residential water use increases at a much higher rate (with the exception of San Francisco). This results from a combination of a projected decrease in household size and a projected increase in population, which translates to more dwelling units, and more outside residential water use for the same population.

For the nine-county Bay Area, outside residential water use with no water conservation is expected to increase about 130 percent while inside residential water use will increase only about 30

TABLE IV-10

PROJECTED RESIDENTIAL AND COMMERCIAL-INDUSTRIAL WATER USE
BY CATEGORY FOR YEAR 2000
(ABAG Base Case 1 Projections)

County	Inside Residential		Outside Residential		Commercial-Industrial		Public Authority		Unaccounted-for	
	mgd	Δ%*	mgd	Δ%	mgd	Δ%	mgd	Δ%	mgd	Δ%
Alameda										
No water cons.	96.4	18.6	52.6	75.3	72.2	17.2	9.8	36.1	19.6	24.8
Alternative 7	84.0	3.3	47.3	57.7	68.6	11.4	9.0	25.0	13.5	-14.0
Contra Costa										
No water cons.	61.5	40.1	69.8	174.8	86.1	29.1	9.1	65.5	16.1	54.8
Alternative 7	52.1	18.7	61.8	143.3	81.8	22.6	8.3	50.9	11.3	8.7
Marin										
No water cons.	20.7	41.8	31.7	153.6	4.8	17.1	3.4	70.0	5.6	64.7
Alternative 7	17.3	18.5	28.2	125.6	4.5	9.8	3.1	55.0	3.7	8.8
Napa										
No water cons.	6.4	25.5	7.1	65.1	7.5	59.6	1.6	60.0	2.5	47.1
Alternative 7	5.4	5.9	6.4	48.8	7.2	53.2	1.4	40.0	1.6	-5.9
San Francisco										
No water cons.	29.3	-4.9	3.8	0.0	53.3	6.2	9.2	2.2	5.2	2.0
Alternative 7	25.2	-18.2	3.6	-5.3	50.6	0.8	8.5	-5.6	3.8	-25.5
San Mateo										
No water cons.	47.3	8.0	33.4	53.2	28.3	15.0	5.3	20.5	3.6	20.0
Alternative 7	41.4	-5.5	30.6	40.4	26.9	9.3	4.8	9.1	3.1	3.3
Santa Clara										
No water cons.	139.8	41.1	90.1	112.0	118.4	52.6	36.1	52.3	28.5	68.6
Alternative 7	119.4	20.5	80.0	88.2	112.5	45.0	33.4	40.9	19.4	14.8

TABLE IV-10
(Continued)

PROJECTED RESIDENTIAL AND COMMERCIAL-INDUSTRIAL WATER USE
BY CATEGORY FOR YEAR 2000
(ABAG Base Case 1 Projections)

County	Inside Residential		Outside Residential		Commercial-Industrial		Public Authority		Unaccounted-for	
	mgd	Δ%*	mgd	Δ%	mgd	Δ%	mgd	Δ%	mgd	Δ%
Solano										
No water cons.	27.4	100.0	31.2	380.0	32.2	131.7	17.0	169.8	5.4	157.1
Alternative 7	22.4	63.5	27.0	315.4	30.6	120.1	15.3	142.9	3.8	81.0
Sonoma										
No water cons.	21.4	55.1	32.3	280.0	12.0	44.6	4.4	120.0	4.8	128.6
Alternative 7	17.3	25.4	28.8	238.8	11.4	37.3	4.0	100.0	3.3	57.1
Bay Region										
No water cons.	450.2	30.1	352.0	126.8	414.8	33.0	95.9	56.7	91.3	51.7
Alternative 7	384.5	11.1	313.7	102.1	394.1	26.4	87.8	43.5	63.5	5.5

*Incremental change from 1975

percent. Although the percentage increase in outside residential water use would be reduced by implementation of water conservation measures, the relative difference between outside and inside use becomes more pronounced because the measures described in Chapter III have a greater effect on inside uses.

Overall commercial-industrial water use in the Bay Area for the next 25 years is expected to increase 33 percent with no water conservation and 26 percent with water conservation as specified for Alternative 7. In counties with projected high growth rates, this increase in commercial-industrial water use is expected to be much larger; for example, in Solano County, an increase in this category of about 130 percent is expected if water conservation is not implemented. Water conservation could reduce this increase by five to 10 percent, and many establishments have already taken measures during the current drought to permanently reduce their water use even more.

Public authority water use in the Bay Area as a whole is expected to increase more than 50 percent by the year 2000, as is unaccounted-for water use, unless water conservation is implemented.

Current and projected daily per capita water use factors, based on residential and commercial-industrial water-use requirements, are presented in Table IV-11. In all counties of the Bay Area, the daily per capita water use is expected to rise above current (1975) values. In the year 2000, San Francisco County would have the lowest factor (162 gpcd if no water conservation is effected) and Solano County would have the highest (333 gpcd with no water conservation). The greatest incremental increase in daily per capita water use over the 25-year planning period with no water conservation (47 percent) would occur in Sonoma County, increasing from 145 gpcd in 1975 to 213 gpcd in 2000. The least 25-year incremental increase with no water conservation (six percent) would occur in San Francisco County, rising from 153 gpcd in 1975 to 162 gpcd in 2000. For the entire nine-county Bay Area, the daily per capita water use with no water conservation would increase from 199 gpcd in 1975 to 235 gpcd in 2000, an increase of 18 percent. With water conservation effected in accordance with specifications for Alternative 2 (see Chapter III), an incremental increase of eight percent would occur for the entire Bay Area during the 25-year period. If water conservation were effected as described for Alternative 7 throughout the Bay Area, a small increase in daily per capita water use, from 199 gpcd in 1975 to 208 gpcd in 2000, would occur.

TABLE IV-11

PRESENT (1975) AND PROJECTED DAILY PER CAPITA
MUNICIPAL WATER USE FACTORS
(gpcd)

County	1975	1980	1985	1990	1995	2000
Alameda						
No water cons.	185	189	196	204	205	203
Alternative 2	-	176	182	188	187	185
Alternative 7	-	173	177	183	183	180
Contra Costa						
No water cons.	271	272	282	295	305	310
Alternative 2	-	254	261	272	280	283
Alternative 7	-	250	255	265	272	275
Marin						
No water cons.	174	191	206	225	227	224
Alternative 2	-	178	190	206	206	202
Alternative 7	-	174	185	197	197	192
Napa						
No water cons.	202	210	220	228	232	238
Alternative 2	-	196	204	211	213	215
Alternative 7	-	193	201	207	208	208
San Francisco						
No water cons.	153	155	159	161	162	162
Alternative 2	-	145	149	150	151	150
Alternative 7	-	142	146	148	148	148
San Mateo						
No water cons.	171	176	184	188	189	189
Alternative 2	-	165	171	175	176	176
Alternative 7	-	162	168	171	171	171
Santa Clara						
No water cons.	227	236	250	255	255	256
Alternative 2	-	221	232	234	233	232
Alternative 7	-	218	227	229	228	227

TABLE IV-11
(Continued)

PRESENT (1975) AND PROJECTED DAILY PER CAPITA
MUNICIPAL WATER USE FACTORS
(gpcd)

County	1975	1980	1985	1990	1995	2000
Solano						
No water cons.	242	273	301	329	342	333
Alternative 2	-	255	279	303	312	302
Alternative 7	-	250	273	295	302	291
Sonoma						
No water cons.	145	171	188	200	208	213
Alternative 2	-	159	173	183	189	192
Alternative 7	-	155	168	177	182	184
Bay Region						
No water cons.	199	208	220	229	234	235
Alternative 2	-	194	204	211	214	214
Alternative 7	-	191	199	206	209	208

Projected Agricultural Irrigation Water Use

Projected total agricultural irrigation requirements by county, with no water conservation and with water conservation effected in accordance with the measures described in Chapter III, for each five-year increment from 1980 to 2000 are presented in Table IV-12. With the exception of San Mateo County, where an increase is indicated, the total agricultural irrigation water requirements are projected to decrease in each county over the period from 1975 to 2000.

The projected percentage increase, or decrease, in agricultural irrigation water requirements over the 25-year period from 1975 to 2000 are shown in Table IV-13. For the entire nine-county Bay Area, it is projected that a decrease in total agricultural irrigation water requirements of 15 percent would occur if no water conservation were effected. A decrease of 30 percent in

TABLE IV-12

PROJECTED TOTAL AGRICULTURAL IRRIGATION WATER USE
(acre-ft/yr)

County	1980	1985	1990	1995	2000
Alameda					
No Water Conservation	18,200	15,700	13,400	11,200	8,900
With Water Conservation	16,200	13,800	11,400	9,200	7,000
Contra Costa					
No Water Conservation	116,100	111,100	105,900	100,900	95,600
With Water Conservation	105,900	100,900	95,700	90,700	85,400
Marin					
No Water Conservation	2,000	1,600	1,600	1,300	900
With Water Conservation	1,800	1,400	1,400	1,000	600
Napa					
No Water Conservation	21,700	21,000	20,800	20,300	19,800
With Water Conservation	20,700	20,000	19,800	19,300	18,800
San Francisco	ALL VALUES ZERO				
San Mateo					
No Water Conservation	8,500	8,800	8,900	9,300	9,700
With Water Conservation	8,000	8,300	8,400	8,800	9,200
Santa Clara					
No Water Conservation	102,400	93,200	85,100	76,700	68,300
With Water Conservation	89,400	80,200	72,100	63,700	55,300
Solano					
No Water Conservation	373,700	373,300	373,200	371,800	369,200
With Water Conservation	295,200	294,800	294,700	293,300	290,700
Sonoma					
No Water Conservation	61,400	57,800	53,300	49,500	45,300
With Water Conservation	55,500	51,900	47,400	43,600	39,400
Bay Region					
No Water Conservation	704,000	682,500	662,200	641,000	617,700
With Water Conservation	592,700	571,300	550,900	529,600	506,400

TABLE IV-13

PROJECTED PERCENTAGE CHANGE IN TOTAL
AGRICULTURAL IRRIGATION WATER REQUIREMENTS
(1975-2000)

County	Percentage Change
Alameda	
No Water Conservation	-57
With Water Conservation	-66
Contra Costa	
No Water Conservation	-22
With Water Conservation	-30
Marin	
No Water Conservation	-62
With Water Conservation	-75
Napa	
No Water Conservation	- 8
With Water Conservation	-13
San Francisco	ALL VALUES ZERO
San Mateo	
No Water Conservation	+18
With Water Conservation	+12
Santa Clara	
No Water Conservation	-38
With Water Conservation	-50
Solano	
No Water Conservation	- 1
With Water Conservation	-22
Sonoma	
No Water Conservation	-31
With Water Conservation	-40
Bay Region	
No Water Conservation	-15
With Water Conservation	-30

agricultural irrigation water requirement would occur for the entire Bay area if water conservation were practiced.

CHAPTER V

REUSE MARKETS FOR RECLAIMED WASTEWATER

INTRODUCTION

Reclamation and reuse of wastewater is not a new concept. Although it has never played more than a minor role in the Bay Area's water supply plans, its use dates back many years. The first reuse project was the reuse of secondary effluent at Golden Gate Park in San Francisco that went into operation in 1932. An average of one million gallons per day (mgd) of reclaimed sewage is used for irrigation of landscaping and filling of recreational lakes in the park.

In 1976 there were over 200 wastewater reuse projects throughout the State, but only 10 projects in operation in the Bay Area. One reason that reuse has not been more extensively practiced in the Bay Area is that the larger sewage treatment plants are located in areas somewhat remote from potential markets and the sewage was inadequately treated for reuse purposes. Recently, however, the Regional Water Quality Control Board has increased the treatment requirements for most treatment plants. Because production of a higher quality effluent has made reuse more cost-effective, the number of reuse projects in the Bay Area is growing steadily.

Wastewater reclamation and reuse can be effective in reducing demands for higher quality fresh water. Demands for industrial water and landscape and agricultural irrigation water can, in many instances, be satisfied with reclaimed wastewater. This substitution can provide an equivalent amount of fresh water to meet growing domestic and commercial water demands. Reuse of reclaimed wastewater has the potential of delaying the need to develop new water supply projects or providing more water in times of drought.

The purpose of this chapter is to identify potential markets for reclaimed wastewater by determining the locations of potential use, type of reuse, quantity of wastewater required, and cost of building and operating identified projects. Proposed projects were screened, based upon public health, technical feasibility, costs, and other factors, to provide a reasonable estimate of the

amount of reuse that might be expected to be or could be implemented and operational between now and the year 2000. To put reuse in the same context of water use and supply, efforts were made to identify the equivalent reduction in use for fresh water due to reuse in contrast to those reuse projects which in effect would create new water use or demand. For example, a reuse project that supplies reclaimed wastewater to satisfy an existing use for industrial process water will be effective in reducing overall demands for fresh water; a project which provides for irrigation of a presently dry-farmed area would not reduce overall demands. The latter type of project could have other benefits, e.g., reduced wastewater discharge, that would justify implementation, but the emphasis in this report has been to find markets for reclaimed wastewater that will result in a reduced demand for fresh water.

No new work on the definition of future reuse markets was done in this study. There are over 60 municipal treatment plants in the Bay Area producing a large (over 500 mgd) but dispersed source of potentially reclaimable wastewater. Reclamation has been evaluated in reports that have accompanied requests for State and Federal sewage treatment plant construction grants for nearly all of these treatment plants. These reports were reviewed during the course of this study and approximately 40 different reuse projects were identified. This approach identified local markets which were generally less than 10 miles from the treatment plant. A report prepared by the California State Department of Water Resources in 1974, entitled "Interagency Water Reclamation Study," which evaluated larger, more regional reuse projects in the Bay Area, was also reviewed. Collectively, these reports provide a representative picture of the potential reuse markets in the Bay Area.

WASTEWATER RECLAMATION AND REUSE

Types of Reuse

Direct Recycle. This type involves extensive treatment of wastewater with subsequent injection into the municipal water supply system.

Groundwater Recharge. This type involves extensive treatment of wastewater with subsequent discharge to the groundwater by direct injection or by percolation through a soil layer.

Agricultural Irrigation. This type involves application of properly treated wastewater to agricultural lands for production of crops.

Landscape Irrigation. This type involves application of treated wastewater to areas covered by vegetation for landscaping purposes. Such areas include parks, golf courses, cemeteries, freeway median strips, and greenery in commercial areas.

Open-space Irrigation. This type involves application of treated wastewater to open-space areas. This normally involves watering unused hillsides. Open-space irrigation is an artificial or created water demand and as such is considered much less desirable than other methods which will supply existing water demands.

Marsh Enhancement. This type involves creating a new fresh water marsh or supplementing natural inflow to an existing marsh with reclaimed wastewater. The purpose is to encourage a balanced ecosystem with a diversity of species. Discharge from the marsh must be designed to be compatible with other beneficial uses in the vicinity.

Recreational Lake. Creation of an artificial lake supplied with reclaimed wastewater provides a recreation site. The impounded water could also be used for irrigation, but recreational use might be limited unless the lake were big enough to avoid undesirable changes in the lake level. Water quality requirements for the effluent depend upon whether public access is allowed and if water-contact sports are to be permitted.

General Industrial Use. This type involves treatment of wastewater with subsequent use by industry. Within this very general classification are many different types of uses, each of which exhibit individual requirements for water quality. Utilization of the industrial market for reclaimed wastewater requires considerable study because of the complex nature of industrial processes.

Industrial Cooling Water. This type involves the use of reclaimed water to remove and transport heat from industrial processing or energy production facilities. There are special quality requirements for water used for this purpose to prevent growth of algae and deposition of solids in heat exchangers and other equipment.

Commercial. Certain commercial water users can make use of reclaimed wastewater. Included are laundries and car washes and other uses where large amounts of water are required.

Fire Protection. This type involves the use of wastewater for fighting or prevention of urban and rural fires. Where industrial use of wastewater occurs, reclaimed water could be used in fire sprinkler systems. In areas with high fire potential, developing and maintaining areas of green vegetation with wastewater could prevent the spread of grass fires.

Miscellaneous Uses. Under this category are methods such as water used in construction for road compaction, use of water at sewage treatment plants for wash water, and irrigation.

Quality Requirements

For some types of reuse, general guidelines can be used to evaluate the suitability of a particular source of reclaimed wastewater.

Public Health Restrictions. Because of uncertainty about the fate and effect of pathogenic viral agents and potentially toxic chemical substances which may be contained in reclaimed wastewater, direct reuse involving human ingestion is not currently acceptable to State and local health authorities. This restriction eliminates the possibility of direct reuse of groundwater injection for subsequent municipal use. Studies are underway to help resolve some of these questions. Applications for permits to dispose of wastewaters through percolation ponds or spray irrigation are evaluated by the health authorities on a case-by-case basis.

Agricultural and Landscape Irrigation and Recreational Lakes. Requirements for the protection of public health from possible contaminants in reclaimed wastewater are based upon the recommendations of the State Department of Public Health as contained in Title 22 of the California Administrative Code. These requirements are summarized in Table V-1. With two exceptions, secondary treatment and disinfection is a basic requirement for treatment when the use approaches direct human contact. In those cases where it may not be practical to control the irrigation method or the type of irrigated crops, the most stringent standard is used for design purposes. The mineral quality of the applied water is another consideration

TABLE V-1

SUMMARY OF STATEWIDE STANDARDS FOR THE REUSE OF RECLAIMED WASTEWATER FOR IRRIGATION AND RECREATIONAL LAKES

Use	Minimum Required Treatment Level	Minimum Bacterial Requirement, Median Coliform, MPN/100 ml
Irrigation		
Fodder, fiber, and seed crops	Primary	No requirement
Processed produce, surface irrigated	Primary	No requirement
Processed produce, spray irrigated	Secondary and disinfected	23
Landscaping, parks, etc.	Secondary and disinfected	23
Produce eaten raw, surface irrigated	Secondary and disinfected	2.2
Produce eaten raw, spray irrigated	Secondary, coagulated, settled, filtered, and disinfected	2.2
Creation of Recreational Lakes		
Landscape impoundment (aesthetic enjoyment only--no public contact)	Secondary and disinfected	23
Restricted recreational impoundment (fishing, boating, nonbody-contact water sports)	Secondary and disinfected	2.2
Nonrestricted recreational impoundment (no limitation on body-contact water sport activities)	Secondary, coagulated, settled, filtered, and disinfected	2.2

with reuse for agricultural irrigation. General guidelines for the potential acceptability of certain reclaimed wastewaters are shown in Table V-2. Table V-3 presents recommended limits for selected trace elements in irrigation waters. The manner and extent to which plants take up heavy metals and other toxic elements is complicated by soil characteristics and plant types, and must be evaluated on a case-by-case basis.

TABLE V-2

QUALITATIVE CLASSIFICATION OF IRRIGATION WATERS

Chemical Properties	Class 1 Excellent to Good	Class 2 Good to Injurious	Class 3 Injurious to Unsatisfactory
Specific electrical conductance, µmhos	< 1,000	1,000-3,000	> 3,000
Total dissolved solids, mg/l	< 700	700-2,000	> 2,000
Chlorides, mg/l	< 175	175-350	> 350
Sodium absorption ratio, me/l	< 6	6-12	12-18

Industrial Use. Quality requirements for industrial process use vary widely. Most frequently, the requirements relate to the total dissolved solids, hardness, alkalinity, color, iron, manganese, and nutrient concentrations. In cooling water applications, the water should not deposit scale, be corrosive, or encourage slime growth.

CRITERIA FOR EVALUATING POTENTIAL REUSE MARKETS

To define the regional Bay Area market for reclaimed wastewater, all published reclamation studies were reviewed on a consistent basis. The criteria used to screen potential markets prior to including them in this study were technical feasibility, public

TABLE V-3

SELECTED RECOMMENDED LIMITS FOR TRACE ELEMENTS IN IRRIGATION WATERS

Element	For Waters Used Continuously on All Soil		For Use Up to 20 Years on Fine Textured Soils of pH 6.0 to 8.5[a]	For Short-term Use On Fine-textured Soils Only[b]
Aluminum	1.0[a]	5.0[b]	20.0	20.0
Arsenic	0.10[a]	1.0[b]	2.0	10.0
Beryllium	0.10[a]	0.5[b]	0.50	1.0
Boron	0.75[a]	0.75[b]	2.0	2.0
Cadmium	0.010[a]	0.005[b]	0.050	0.05
Chromium	0.10[a]	5.0[b]	1.0	20.0
Cobalt	0.50[a]	0.2[b]	5.0	10.0
Copper	0.20[a]	0.20[b]	5.0	5.0
Fluoride	1.0[a]	--	15.0	--
Iron	5.0[a]	--	20.0	--
Lead	5.0[a]	5.0[b]	10.0	20.0
Lithium	2.5[a]	5.0[b]	2.5	5.0
Manganese	0.20[a]	2.0[b]	10.0	20.0
Molybdenum	0.005[a]	0.010[b]	0.050	0.05
Nickel	0.20[a]	0.5[b]	2.0	2.0
Selenium	0.020[a]	0.05[b]	0.020	0.05
Vanadium	0.10[a]	10.0[b]	1.0	10.0
Zinc	2.0[a]	5.0[b]	10.0	10.0

[a] "Water Quality Criteria, 1972", Environmental Study Board of the National Academy of Science and the National Academy of Engineering, U.S. Government Printing Office.

[b] "Report of the Committee on Water Quality Criteria", Federal Pollution Control Administration, p. 148, April 1968.

health, and economic factors. The manner in which these factors were used is described below.

Technical Feasibility

Each individual reclamation report reviewed during the course of this study had considered other potential markets in the general vicinity of the sewage treatment plant prior to recommending the apparent most feasible markets to be served by the proposed project. It was assumed in this study that quality requirements of the markets had been appropriately matched with reclaimed wastewater quality. Consequently, all published potential markets were considered technically feasible.

The quantities of reclaimed wastewater that were to be provided were checked against the municipal wastewater flow projections developed by ABAG. In a few cases the wastewater that was expected to be reclaimed and reused exceeded the amount of ABAG's projection at the particular treatment plant. Therefore the quantity of reclaimed wastewater provided to the market was reduced to match the amount of wastewater available.

Environmental

In a few cases in the Bay Area, reuse of reclaimed wastewater by groundwater recharge via percolation ponds into aquifers used for general municipal purposes has been proposed in previous studies. These proposals have not met with approval of the State Department of Health and the projects were subsequently abandoned. These projects were treated separately in this study and not included in the Bay Area market projection. Because the potential market is large, however, the quantities of reclaimed wastewater that could be used for recharge have been tabulated in the event that the public health problems are resolved in the future.

Economic Factors

In some previous studies, costs for implementing proposed reclamation projects were given and the economic feasibility of the project was established. This was normally done by comparing the cost of providing reclaimed wastewater with the normal water supply in the area on a unit cost basis. If the cost of providing reclaimed wastewater was less than the normal

water supply, the project was considered economically feasible; however, if the reclaimed wastewater was more expensive, the project should not be eliminated outright. The local water demand and supply situation must be evaluated with reclaimed wastewater representing one alternative source of supply. In some instances the reclaimed wastewater reuse project might be eligible for a State and Federal construction grant, especially if reclamation costs less than treatment and disposal; these grants could substantially reduce the cost of reclaimed water.

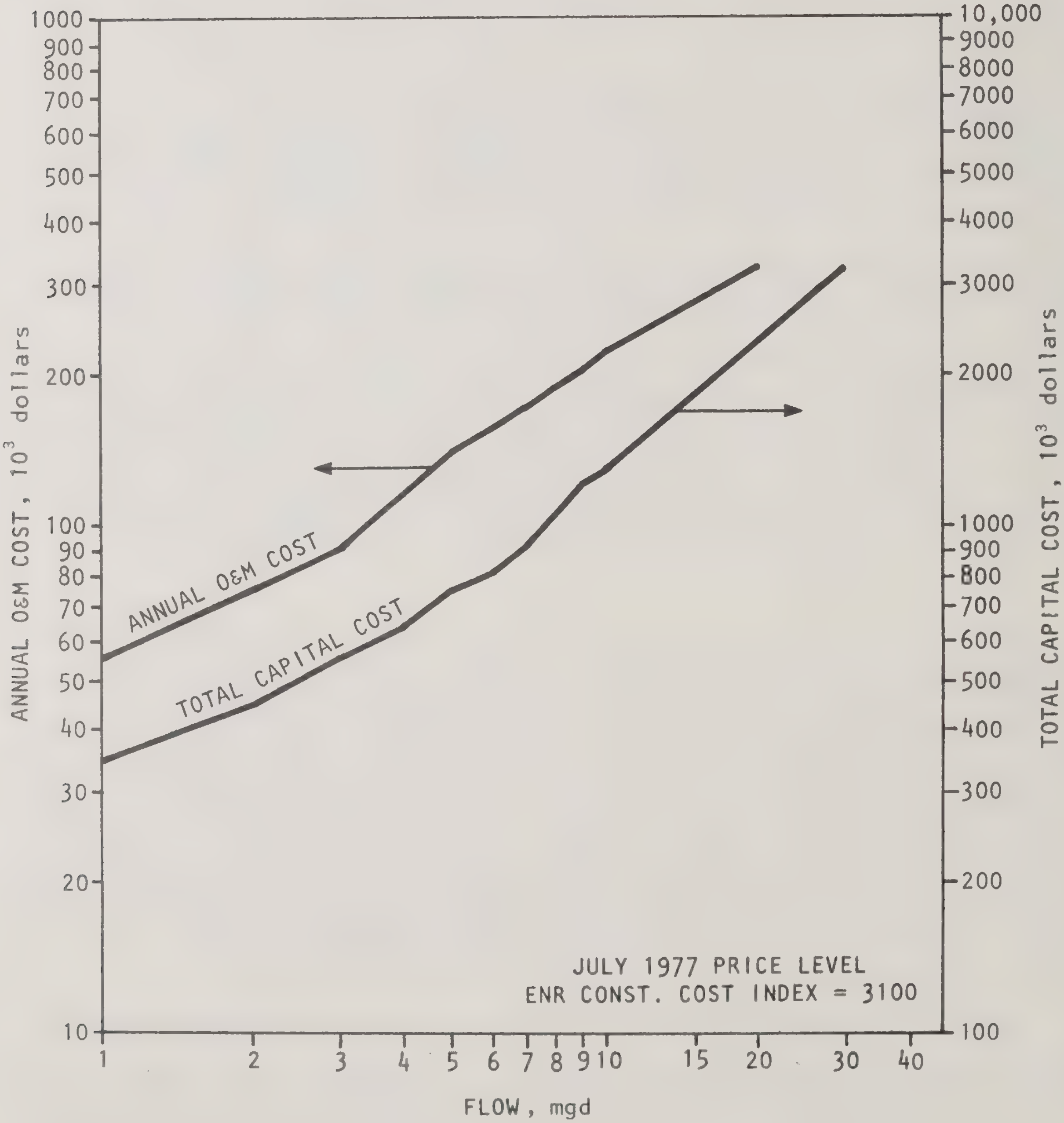
In cases where costs were not provided in published reports, the following procedure was used. Only treatment costs above that required for wastewater disposal were considered. Costs of secondary effluent filtration were based upon cost curves developed by Lee Saylor, Inc. based upon a recent (February 1974) report for EBMUD's water reclamation project [Reference 29]. These curves were updated to an Engineering News Record (ENR) Index of 3100 (June 1977) from the value of 2287 that applied in 1974, and are shown on Figure V-1. Costs for treatment in excess of filtration were obtained directly from reports describing the particular reclamation project and updated to an ENR Index of 3100.

Cost of conveyance of reclaimed wastewater from the treatment plant to the point of reuse was estimated using the relationship shown in Figure V-2. Costs include a buried force main, a pump station capable of pumping twice the average daily use during the period of use, and storage of one-half day's use in a steel tank located at an elevation 150 feet above the point of reuse to provide the system with sufficient delivery pressure (60 psi). Costs are dependent upon the distance to the market and the amount of water pumped. Normal water distribution costs, are on the order of $0.50 to $1.00 per 1,000 gallons. Costs of any additional treatment must be added to those costs shown in Figure V-2. Availability of grants, a water shortage, or other extenuating circumstances must be taken into account in determining economic feasibility.

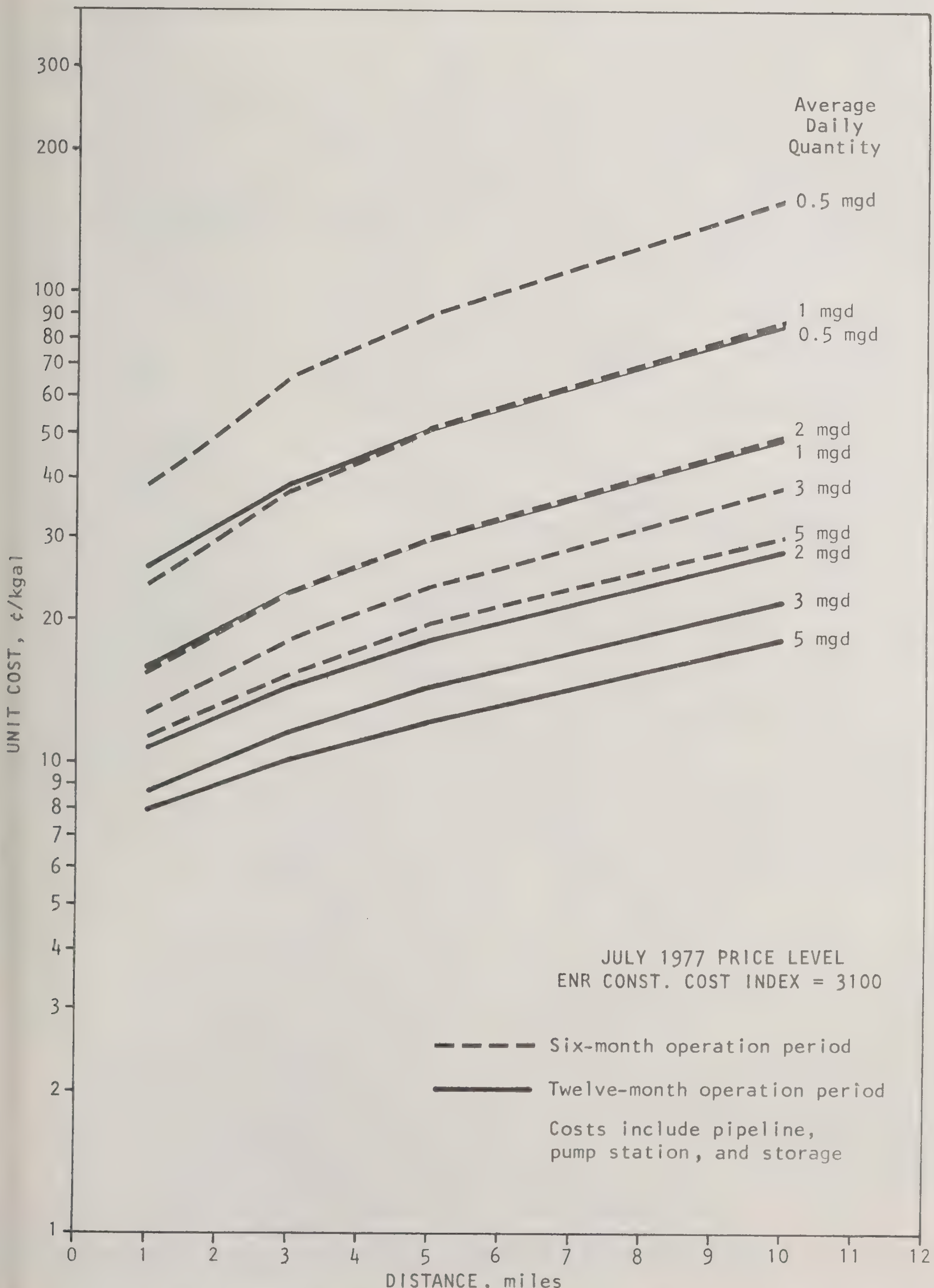
DESCRIPTION OF MARKETS FOR RECLAIMED WASTEWATER

Projection Methodology

Within the Bay Area, approximately 40 existing and potential reclamation-reuse projects were identified. These markets fell



SOURCE: LEE SAYLOR, INC.	SECONDARY EFFLUENT FILTRATION COSTS JBGA/WOM/RTC 7/77 FIGURE V-1



RCE: LEE SAYLOR, INC.

COST OF CONVEYANCE FOR RECLAIMED WASTEWATER

JBGA/WOM/RTC 7/77

FIGURE V-2

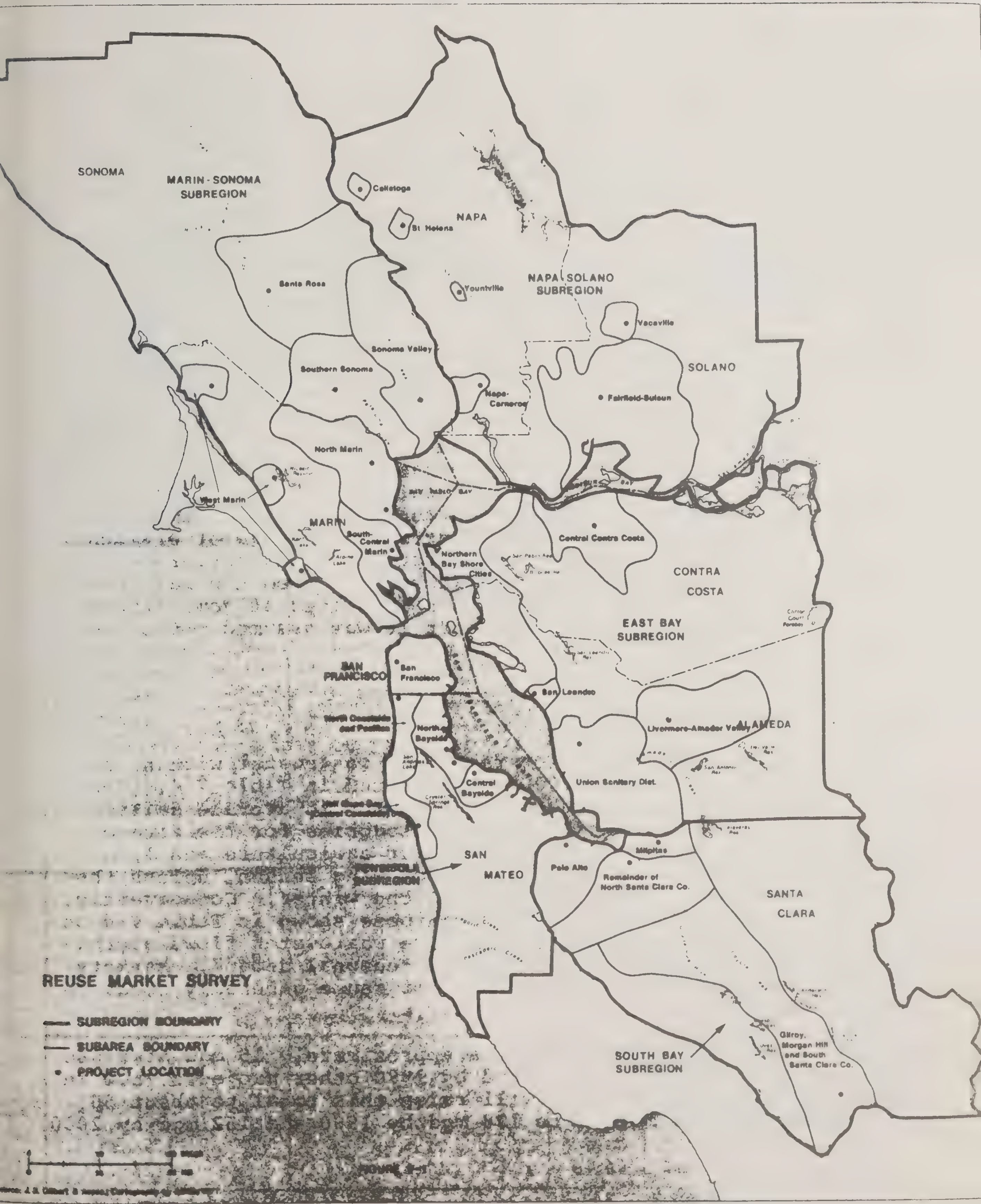
into the twelve categories described above. Geographically they are distributed throughout the Bay Area. Subareas that would be served by the individual projects are shown in Figure V-3. Within each subarea, potential markets were reviewed and certain ones selected for service by the reuse project. Project locations are also shown on Figure V-3. These subareas were grouped into five subregions, consistent with the water supply element of this report, as follows:

1.	Peninsula	San Francisco and San Mateo counties
2.	South Bay	Santa Clara County
3.	East Bay	Alameda and Contra Costa counties
4.	Napa-Solano	Napa and Solano counties
5.	Marin-Sonoma	Marin and Sonoma counties

The reuse projection was developed as follows: If a particular reuse project was in the design or 201 facility planning stage and appeared to be proceeding towards implementation, it was assumed the project would be on-line by 1980. If, however, the project had unresolved institutional or financial aspects, or if the facility planning had not yet begun, it was assumed the project would be on-line by 1985. If a particular project was in the very preliminary planning stages, but appeared to be feasible, i.e., it had no major public health or other apparent problems, it was assumed that it could not go on-line until 1990. In each case the annual quantity of proposed reuse was checked against the ABAG wastewater projection, and in cases where all the wastewater was being reused over a period of six to 12 months, the reuse quantity was increased over time through the year 2000 in proportion to the wastewater flow projection. In this way the cumulative annual quantities of reuse in each category for each area of the subregion were developed. Totals for the subregion were then made by adding up all the reuse in the areas.

Export of Reclaimed Wastewater From the Bay Area

Transfers of reclaimed wastewater from one region to a market in another region were not considered in this study. On a small scale the costs of transporting wastewaters can be expensive (cf. Figure V-2). The economies of scale associated with much larger projects has been evaluated by the California Department of Water Resources, Central District. This study [Reference 30] considered reusing all the treated municipal wastewater from the East Bay and South Bay subregions and in some cases also from the Peninsula subregion, including San Francisco. It was proposed


SONOMA
MARIN-SONOMA SUBREGION
Calistoga
St Helena
NAPA
Santa Rosa
Yountville
NAPA SOLANO SUBREGION
Vacaville
Sonoma Valley
Southern Sonoma
SOLANO
Napa-Carneros
Fairfield-Suisun
North Marin
West Marin
MARIN
South-Central Marin
Central Contra Costa
Northern Bay Shore Cities
CONTRA COSTA
EAST BAY SUBREGION
SAN FRANCISCO
San Francisco
San Leandro
North Bayside
Livermore-Amador Valley
ALAMEDA
Central Bayside
Union Sanitary Dist.
Milpitas
SAN MATEO
Palo Alto
Remainder of North Santa Clara Co.
SANTA CLARA
REUSE MARKET SURVEY
SUBREGION BOUNDARY
SUBAREA BOUNDARY
PROJECT LOCATION
SOUTH BAY SUBREGION
Gilroy, Morgan Hill and South Santa Clara Co.

that this wastewater be reused for agricultural irrigation in the San Joaquin Valley or for increasing Sacramento-San Joaquin Delta outflow by release at Chipps Island or a combination of this and power plant cooling, Suisun Marsh management, and irrigation in the Contra Costa-Solano counties area. Costs reported in that report ranged from $77.00 to $125.00 per acre-foot of water. In the time since these costs were estimated (January 1973), construction cost indexes have risen 50 percent and energy costs have doubled. Conceivably, these project costs could be about 80 percent higher in 1977, because the alternatives considered are energy intensive, requiring pumping of large quantities of water. Export of from 360,000 to 650,000 acre-feet/year of wastewater effluent was considered. Costs to farmers for irrigation water in the Central Valley are now much less than this, ranging from $12.00 to $50.00 per acre-foot. There is thus the incentive for the agricultural water users to use their present source of water unless they need another source of supply and can find a way to equitably share the costs. Many wastewater dischargers in the Bay Area have or are presently in the process of upgrading their treatment plants to meet San Francisco Bay water quality standards for discharge of effluent; thus there is also little incentive for these dischargers to pay the additional costs of exporting wastewater from the Bay Area. Although this export project may be reinitiated at some future date, for the purposes of this report it was assumed not to be economically feasible.

Summary of Bay Area Markets

The estimated reuse market for reclaimed wastewater within the Bay Area through the year 2000 is presented in Table V-4. The amount of projected reclaimed wastewater on an average daily basis has been summarized into four categories for the five subregions in the Bay Area. Markets for agriculture and landscape actually occur only during the growing season, unless the reclaimed wastewater is stored during the winter. Consequently, the total amounts of reuse for the purpose shown in Table V-4 on an average daily basis actually require wastewater flows approximately twice this amount to meet the seasonal demand. Markets for industrial reuse and other types of reuse generally occur on a year-round basis.

Presently in the Bay Area there is approximately 15 mgd of reuse on-line or under construction and by 1980 other projects (now in the detailed planning phase) will raise this total to about 50 mgd. To expand the market to 138 mgd by 1990 and 152 mgd by 2000

TABLE V-4

RECLAIMED WATER MARKETS IN THE BAY AREA
(mgd)

Subregion/Market	Existing or Under Construction	1980	1985	1990	2000
Peninsula					
Agriculture	0	0	0	1.10	1.10
Landscape	2.42	2.48	7.63	10.37	10.41
Industrial	0	0	1.15	1.52	1.52
Other	0	0	0.17	0.17	0.17
Total	2.42	2.48	8.95	13.16	13.20
South Bay					
Agriculture	0.44	3.60	4.48	5.44	7.77
Landscape	0.30	0.30	2.23	7.66	9.08
Industrial	0	0	0	1.23	1.23
Other	3.12	3.12	3.12	5.12	5.12
Total	3.86	7.02	9.83	19.45	23.20
East Bay					
Agriculture	2.74	2.74	3.97	6.47	6.47
Landscape	0.36	0.36	2.97	2.97	2.97
Industrial	0	15.01	41.73	41.73	41.73
Other	1.00	2.00	3.48	3.48	3.48
Total	4.10	20.11	52.15	54.65	54.63
Napa-Solano					
Agriculture	0.30	14.41	16.74	19.21	25.29
Landscape	0	0.12	0.12	0.14	0.14
Industrial	0	0	0	0	0
Other	0	3.84	5.75	8.22	8.22
Marin-Solano					
Agriculture	3.99	13.49	17.32	21.63	25.34
Landscape	0.04	0.66	0.82	1.61	2.19
Industrial	0	0	0	0	0
Other	0	0	0	0	0
Total	4.03	14.15	18.14	23.24	27.53
Bay Region					
Agriculture	7.47	34.24	42.51	53.85	65.97
Landscape	3.12	3.92	13.77	22.75	24.79
Industrial	0	15.01	42.88	44.48	44.48
Other	4.12	8.96	12.52	16.99	16.99
Total	14.71	62.13	111.68	138.07	152.53

will require impetus to implement additional projects that are now only in the conceptual stage but which did pass the technical, environmental, and economic screening criteria imposed in this study. Overall in the Bay Area, 43 percent of the projected reuse would be by agriculture, 16 percent would be for landscape irrigation, 30 percent would be by industry, and 11 percent would be for other uses.

The amounts of projected municipal and industrial wastewater and the percentage of reuse through the year 2000 are presented in Table V-5. The wastewater flow projections were developed by ABAG based upon their Provisional Series 3 Projections, Base Case 1. Presently the Bay Area is reusing approximately 2.7 percent of its wastewater. By 1980 this is expected to increase to 10.0 percent. After 1990 the percentage should be on the order of 21 percent. The percentage in the year 2000 will be the highest in Napa-Solano subregion (64.7 percent) and the lowest in the Peninsula subregion (7.2 percent).

A list of the projects included in the reuse market survey is presented in Table V-6. All these projects were judged to be technically, environmentally, and economically feasible. The implementing agency and projected annual volume of reuse in the year 2000, and type of project are shown. Costs have been estimated as described previously and include treatment and distribution for the ultimate design capacity. To compute annual capital costs a useful economic life of from 20 to 50 years, depending upon the type of structure or equipment, was used together with an interest rate of 6-3/8 percent. Unit costs are expressed at full capacity in dollars per acre-foot and cents per 1,000 gallons (¢/kgal). Unit costs for the Bay Area are on the order of $130/acre-ft or 40¢/kgal. The unit costs range from a low of $40/acre-ft (12.2 ¢/kgal) to a high of $782/acre-ft (240 ¢/kgal). Weighted average costs for the five subregions range from $64/acre-ft (19.4 ¢/kgal) in the Napa-Solano subregion to $167/acre-ft (50.6 ¢/kgal) in Contra Costa County. Differences in costs are due to required treatment levels and conveyance distances.

Costs for reuse are summarized for each subregion and are compared to costs of other forms of water supply, such as water conservation and imported water, in Chapter VI.

A detailed breakdown on the projected annual quantities of reuse for each project are tabulated in Appendix A. Also shown in these tables are the distance to the market from the reclamation

TABLE V-5

EXISTING AND PROJECTED MUNICIPAL-INDUSTRIAL WASTEWATER REUSE

Subregion	Existing		1980		1985		1990		2000	
	mgd	% Reuse	mgd	% Reuse	mgd	% Reuse	mgd	% Reuse	mgd	% Reuse
Peninsula	164.0	1.5	168.2	1.5	172.9	5.2	178.6	7.4	183.8	7.2
South Bay	136.7	2.8	178.8	3.93	188.3	5.2	197.3	9.9	211.4	11.0
East Bay	202.7	2.0	201.0	10.0	211.3	24.7	222.0	24.6	232.1	23.5
Marin-Sonoma	32.6	12.4	37.8	37.4	44.0	41.2	52.1	44.6	57.6	47.8
Napa-Solano	14.0	2.1	32.7	56.2	37.8	59.8	42.6	64.7	52.0	64.7
Bay Region	550.0	2.7	618.5	10.0	654.3	17.1	692.6	19.9	736.9	20.7

Source: ABAG, Water Quality Technical Memorandum No. 15, June 8, 1977.

TABLE V-6

ESTIMATED COSTS OF REUSE

Project Area	Implementing Agency	Ult. Annual Reuse 10^6 gal	Types of Reuse[a]				Capital[b] Cost, $	O&M, $/yr	Unit Cost	
			A	L	I	O			$/acre-ft	¢/kgal
Peninsula subregion										
San Francisco	City & County of San Francisco	720		x			1,327,000	86,000	87	26.7
North Coastside & Pacifica	North San Mateo Co. SD	942		x		x	3,600,000	120,000	168	51.6
Central Coastside	City of Half Moon Bay	500	x	x			1,361,000	79,500	151	46.5
North Bayside	Cities of San Bruno, So. San Francisco, Millbrae, Burlingame	2,189		x		x	4,523,000	200,500	115	35.2
Central Bayside	City of San Mateo	465		x		x	1,941,614	75,500	133	40.6
Subtotal		4,817					12,752,614	581,500	126	38.7
South Bay subregion										
Palo Alto	City of Palo Alto	2,685		x		x	11,000,000	196,500	217	66.7
Milpitas	City of Milpitas, Santa Clara Valley WD	685	x				1,530,000	85,500	96	29.3
Remainder Santa Clara Co.	Santa Clara Valley WD	2,500		x			11,498,000	298,000	147	45.1
Gilroy-Morgan Hill	Cities of Gilroy-Morgan Hill	2,600	x		x		2,052,000	88,000	21	6.5
Subtotal		8,470					26,080,000	668,000	126	38.8
East Bay subregion										
Northern Bay Shore Cities	EBMUD	5,015		x	x	x	27,700,000	1,037,000	285	87.4
San Leandro	EBMUD	530		x	x	x	1,130,000	27,000	214	65.6
Union Sanitary District	Union Sanitary District	2,530	x	x	x	x	12,700,000	52,000	136	41.9
Livermore-Amador Valley	LAVMA	910	x				1,942,000	75,500	130	40.0
Central Contra Costa	Central Contra Costa SD, Contra Costa County WD	10,960			x		20,000,000	1,205,000	79	24.3
Subtotal		19,945					63,472,000	2,386,500	144	44.1
Napa-Solano subregion										
Napa-Carneros	Napa Co. Flood Control & WCD	1,500	x				1,850,000	37,000	51	15.5
Yountville	City of Yountville, Veterans Home	130	x	x			309,000	12,000	205	63.0
Calistoga	City of Calistoga	100	x				200,000	12,000	120	36.8
St. Helena	Pacific Union College	50	x					EXISTING PROJECT		
Fairfield-Suisun	City of Fairfield, Solano ID	7,300	x			x	5,240,000	497,000	40	12.2
Vacaville	City of Vacaville, Solano ID	3,200	x				7,600,000	258,500	116	35.4
Subtotal		12,280					15,199,000	816,500	64	19.4
Marin-Sonoma subregion										
South-Central Marin	Marin Municipal WD	200		x			480,000	31,500	116	35.6
North Marin	Las Gallinas SD, Novato SD	1,700	x	x			1,764,000	165,800	60	18.4
West Marin	North Marin Co. WD	70	x				790,000	21,500	782	240.0
Southern Sonoma	City of Petaluma	2,700	x				10,600,000	600,000	215	65.8
Sonoma Valley	Sonoma Valley Co. SD	1,380	x				2,000,000	60,000	59	18.2
Santa Rosa	City of Santa Rosa	4,000	x					EXISTING PROJECT		
Subtotal		10,050					15,634,000	878,800	139	42.6
Bay Region		55,562					133,137,600	5,331,300	121	37.1

[a] Type of Reuse: A, Agricultural irrigation; L, Landscape irrigation; I, Industrial; O, Other
[b] 19[illegible] dollars, [illegible] by State or Federal funds

plant, the treatment required, the average daily design capacity selected for cost estimating purposes, operation period, estimated capital and operation and maintenance costs, implementing agency, and a reference for the project market.

In the following paragraphs the reuse markets in each subarea that contributed to the total quantities listed in Table V-6 are briefly described.

Peninsula Subregion

City of San Francisco. The City of San Francisco has provided 1.0 mgd of reclaimed wastewater for landscape irrigation in Golden Gate Park since 1932. The plant could be expanded to approximately 4.0 mgd to meet the rest of the needs of the park. Reuse of 4.0 mgd during the summer six-month growing season is assumed.

North Coastside and Pacifica. The North San Mateo County Sanitation District is presently constructing secondary treatment facilities. A contract to supply the Olympic Golf Course with reclaimed wastewater has been executed and other markets exist in the vicinity. Up to 4 mgd of reuse for landscape irrigation during the growing season is expected to be on-line by 1990.

Central Coastside. Initial reuse efforts in the Half Moon Bay area are being directed at supplying the local golf course with 0.3 mgd during the summer. Later, probably by 1990, 2 mgd of the effluent will be used for agricultural irrigation in the Half Moon Bay area.

North Bayside. The reuse market that could be served from the City of Burlingame, the City of South San Francisco, and several other smaller treatment plants includes landscape irrigation and industrial cooling. Up to 9 mgd could be supplied using three reclamation plants to minimize conveyance distance.

Central Bayside. The City of San Mateo is constructing a project to supply the city golf course and parks in Foster City with reclaimed wastewater for landscape irrigation. The project will begin with 2 mgd and expand to 3 mgd by 1990.

South Bayside. The cities of Redwood City, San Carlos, and Menlo Park are constructing a regional plant at Redwood Shores.

The reuse market, which is landscape and industrially oriented, is considered too dispersed to be economically feasible and, although the reuse was shown in the various categories in Appendix A, the project is considered infeasible.

South Bay Subregion

Palo Alto. The City of Palo Alto has a 4 mgd advanced waste treatment plant under construction. Of this total, approximately 2 mgd will be injected into groundwater aquifers south of the treatment plant near Moffett Field Naval Air Station. Previously, pumping was causing salt water intrusion from the Bay. The injected water will form a salt water intrusion barrier. A series of extraction wells is an essential feature of the project and will prevent migration of the injected reclaimed wastewater to points of potential human use. The other 2 mgd will be used to irrigate the city golf course and perhaps nearby parks and freeway interchanges. There are plans to investigate expanding the groundwater injection portion of the project. It is assumed in this study that an additional 2 mgd could be used in this manner by 1990.

Milpitas. The Santa Clara Valley Water District is investigating renovating the abandoned Milpitas sewage treatment plant and supplying nearly 4 mgd of reclaimed wastewater to local farmers for irrigation. Facility planning is underway and the project could be on-line as early as 1980.

Remainder of North Santa Clara County. A market for landscape irrigation water in the Santa Clara-San Jose area has been identified. Over 5 mgd could be reused during the summer months. However, an extensive network of piping would be needed due to the dispersed market.

Studies completed for the Santa Clara Valley Water District investigated in detail the potential for using 70 to 110 mgd of reclaimed wastewater from the new San Jose treatment plant as well as other plants in the area for groundwater recharge via percolation ponds. However, due to opposition from the State Department of Health, the project was abandoned. The potential remains, however, should possible health problems be resolved by on-going and future research concerning these matters.

Gilroy-Morgan Hill. The City of Gilroy is building an emergency, drought-relief reclamation project. The project

would have the capability to convey up to 2 mgd to farmers west of the city along Hecker Pass Highway. Secondary effluent will be provided from the existing treatment plant. Further reuse by agriculture is planned for treated wastewater from the proposed new regional Gilroy-Morgan Hill treatment plant. Ultimately all of the flow, projected to be 12 mgd in year 2000, will be reused during the summer months.

East Bay Subregion

Northern Bay Shore Cities. East Bay Municipal Utility District (EBMUD) is investigating several alternatives in the area from Richmond to Rodeo. The market includes two oil refineries and a chemical plant for cooling water. Reclaimed wastewater could also be provided to several parks and golf courses along the way. The maximum size alternative would be approximately 12 mgd. Some potential customers in this area and in other parts of EBMUD's service area have reduced their dependence on delivered waters by in-house recycling and drilling wells. This has had the desired effect of reducing total water usage in the region, and has not required any capital investment by EBMUD.

San Leandro. EBMUD and the City of San Leandro are evaluating the reuse of effluent from the San Leandro treatment plant for irrigation of golf courses and parks in the vicinity of the treatment plant. About 1.0 mgd could be reused in the summer. In a separate project, facilities for recycling of backwash water at EBMUD's San Leandro water treatment plant are being constructed. This will make an additional 1.0 mgd of fresh water available.

Union Sanitary District. Up to 10 mgd could be reused in the Union City-Newark area for a variety of purposes. However, only 7 mgd of reuse in the Union City area appears economically feasible. This amount would be distributed as follows: agricultural irrigation, 4 mgd; landscape irrigation, 1 mgd; marsh enhancement and duck clubs, 1.5 mgd; and industrial, 0.5 mgd. Winter flows would be stored in a 1,200-acre lake. The project was initially intended to determine if the reclamation market could eliminate connection to the East Bay Dischargers' outfall. Because the market proved insufficient, some of the incentive for the project has been removed. Because further studies are planned by the East Bay Dischargers Authority, it was assumed that the project would not be built until 1985.

Central Contra Costa. The Central Contra Costa Sanitary District (CCCSD) and the Contra Costa County Water District (CCCWD) are constructing what will be the largest reuse project in the Bay Area. Fifteen mgd of filtered secondary effluent from CCCSD's new treatment plant will be pumped to a softening plant operated by CCCWD. The first part of the project has been completed and the ion-exchange water softening plant will be built in 1977. Water will be pumped by CCCWD to the Martinez area for use by refineries, chemical plants, and a power plant. This water will be used for cooling on a year-round basis. The project is expandable to 30 mgd with the next 15 mgd being used for industrial process water. The wastewater available at CCCSD's plant in 1990 will be about 43 mgd. There are some indications that additional water could be used by industries in the Antioch-Pittsburg area and for agricultural irrigation in the Brentwood area; however, further study would be needed to confirm these markets.

Livermore-Amador Valley. Reclaimed wastewater is presently being used at the Livermore and Pleasanton treatment plants for agricultural and landscape irrigation. Approximately 3 mgd of secondary effluent is being reused. Present plans for wastewater discharge call for export of wastewater out of the valley, however, due to the adverse effects this method of disposal has had upon the groundwater basin. It is assumed that, due to water needs in the valley by 1990, similar reuse of about 3 mgd will recur with wastewater treated to a higher degree than is presently provided.

Marin-Sonoma Subregion

South-Central Marin. The City of Mill Valley is proceeding with a project to take effluent from their treatment plant and reuse it on their golf course. The project would have a capacity of about 0.5 mgd, but could expand in the future.

North Marin. The Las Gallinas Valley Sanitation District and the Marin Municipal Water District have a 1.0 mgd reclamation plant. They plan to irrigate McInnis Park and the Marin Civic Center grounds with filtered secondary effluent.

Experimentation with reuse of effluent from the Novato Sanitary District's Novato Main Plant for agricultural irrigation began in 1976. The District's outfall passes

near sufficient acreage to eventually reuse all the effluent during the growing season (6 mgd in year 2000). It was assumed that this project would be implemented on a small scale by 1980.

West Marin. The existing Bolinas treatment plant's secondary effluent is reused for year-round pasture irrigation. Tomales Bay and Pt. Reyes plan similar projects which are being implemented by the North Marin Municipal Water District. Winter storage will be provided and the irrigated area will be owned by the local sewerage agency.

Southern Sonoma. The City of Petaluma is in the process of facility planning for a project for year-round reuse. Winter flows would be stored if a suitable reservoir site can be found, permitting all reclaimed wastewater to be used for pasture and field crop irrigation in the Petaluma area. Initially the project would provide 4 mgd of secondary effluent on a year-round basis and 7.5 mgd could be provided in year 2000.

Sonoma Valley. The Sonoma Valley County Sanitation District is designing a year-round reuse project. Winter flows would be stored in a 1,200 acre-foot reservoir and secondary effluent would be distributed to farmers in the southern Sonoma Valley area. Reuse will increase from 2 mgd on an annual basis to nearly 4 mgd by the year 2000.

Santa Rosa. The City of Santa Rosa began reclaiming all of its wastewater in 1977 for reuse on farms in the Santa Rosa Plain. No winter storage is provided, but reuse is expected to grow from about 8 to 20 mgd by the year 2000 during the growing season.

Napa-Solano Subregion

Napa-Carneros Area. The Napa County Flood Control and Water Conservation District has studied the possibility of pumping the Napa County Sanitation District's effluent across the river for reuse by agriculture in the Carneros area. The reclaimed wastewater would be reused for frost protection in the winter and spring, and irrigation of vineyards and field crops in the summer. It was assumed in this study that 2 mgd could be used in the winter and 4 mgd in the summer.

Yountville. The City of Yountville is planning to combine with the existing State Veterans' Home reuse project. Approximately 0.3 mgd would be reused for landscape irrigation and 0.5 mgd would be reused for agricultural irrigation. The latter reuse project would be a small expansion of the existing Veterans' Home project.

St. Helena. Pacific Union College at Angwin has operated a small reclamation plant (0.1 mgd) for many years. Effluent is provided for agricultural irrigation and it is assumed that this will continue.

Calistoga. The City of Calistoga has completed facility planning for a landscape irrigation reuse project. Tertiary treated effluent (0.4 mgd) will be pumped to a county golf course and several other areas during the summer.

Fairfield-Suisun. The City of Fairfield is designing a treatment plant that will provide 12 mgd of secondary, filtered effluent. The proposed year-round reuse project involves providing water to farmers in the Fairfield area during the growing season and using the effluent to augment fresh water inflow to the Suisun Marsh during the nongrowing season. By the year 2000 up to 20 mgd of wastewater will be available for reuse in this manner.

Vacaville. The City of Vacaville is negotiating with the Solano Irrigation District for the latter agency to take reclaimed wastewater from the Vacaville plant and convey it to local farmers. The project would be designed for 6.5 mgd and would provide effluent on a year-round basis as a result of winter storage. Implementation is proceeding slowly due to institutional problems, but it is assumed to be on-line by 1975.

IMPACT OF REUSE ON WATER DEMANDS

To put the potential amount of wastewater in the Bay Area in the perspective of an alternative source of water supply, it is desirable to estimate the water savings that would be achieved if these reuse projects were implemented. Nearly all of the proposed reuse for agricultural irrigation would be used to irrigate new areas. In many cases it was found that the farmers who expressed an interest in reclaimed wastewater had no other

alternative source of water. Some of the other reuse projects, including supply to recreational lakes or enhancement of marshes, were also, in effect, creating a new water use and would not be implemented if wastewater were not available. These demands were not included in the projection of future fresh water demands made in this study and presented in Chapter IV. Therefore, to be consistent with the water-use projections, these quantities were subtracted from the amounts shown in Table V-4 to determine the estimated water savings associated with reuse. This is not meant to imply that these reuse projects are of no value, but that they will not free up a like amount of fresh water for another use.

By the year 2000 it is projected that about one-half of potential wastewater reuse will be accommodated by industry. EBMUD found that the process of facility planning for the implementation of a reuse project encouraged the potentially affected industries to use less water by reducing waste, by modifying processes, or by recycling their own wastewater. For example, the initial estimate of the market at Standard Oil Refinery was 8 mgd, but in-plant water conservation by Standard Oil reduced the market to 6 mgd. Kellogg Cereal's initial potential market was estimated to be 0.5 mgd, but this was eliminated because they decided to recycle their own effluent. Thus a portion of the industrial reuse market may be serviced by recycling industrial effluent rather than by using municipal effluent. These actions have the desired overall effect on reducing demand for freshwater as well as reducing total wastewater discharges.

Estimated reductions in Bay Area water use that would occur if all reuse markets, except those which create a new water use, were implemented are presented in Table V-7. In 1980 approximately 42 mgd of fresh water could be saved, in 1990 approximately 98 mgd could be saved, and by the year 2000 about 108 mgd savings could be realized.

TABLE V-7

ESTIMATED REDUCED WATER DEMANDS DUE TO
IMPLEMENTATION OF WASTEWATER RECLAMATION
(mgd)

Subregion	1980	1985	1990	2000
Peninsula	2.5	9.0	12.1	12.1
South Bay	7.0	9.8	19.5	23.2
East Bay	17.3	43.0	45.5	45.5
Marin-Sonoma	1.6	1.9	3.1	3.8
Napa-Solano	13.2	15.5	17.7	23.5
Bay Region	41.6	79.2	97.9	108.1

CHAPTER VI

REGIONAL WATER RESOURCES ASSESSMENT

INTRODUCTION

The purpose of this chapter is to integrate water supply, water conservation, and wastewater reclamation into an overall water resources plan for the Bay Area. The effects of water conservation and wastewater reuse on projected water use and the need for new water supplies are analyzed and presented. The costs of water conservation and reuse are compared with the costs of developing new water supplies to assess their relative cost-effectiveness.

It is not the intent of this report to conclude whether certain new water supply projects should be built. Rather, the purpose is to suggest priorities on water conservation, reuse, and supply elements for subregions of the Bay Area. Priorities are based upon implementing the least costly, in terms of unit cost of developed water, projects first. Ultimately, all proposed project alternatives may require implementation to provide sufficient water supply to the Bay Area.

In addition to water supply and use considerations and cost-effectiveness, this chapter will address institutional and financial arrangements required to implement the various alternatives. The institutional section emphasizes better regional coordination of water conservation, wastewater reclamation, and potential water exchanges and suggests formation of a new regional committee to achieve this. Alternatives are also assessed for environmental and social impacts. This latter assessment is designed to show cause-and-effect relationships, whether they be direct or indirect, significant or insignificant.

ENVIRONMENTAL ASSESSMENT

The alternatives for water conservation, reuse, and supply will have direct impacts on water resources and direct and indirect effects on physical resources, energy, and amenities. The most

important environmental impacts of this plan are those related to water resources. Consequently a quantitative analysis was developed to assess these impacts. Impacts in other categories were assessed in a qualitative manner.

Water Resources

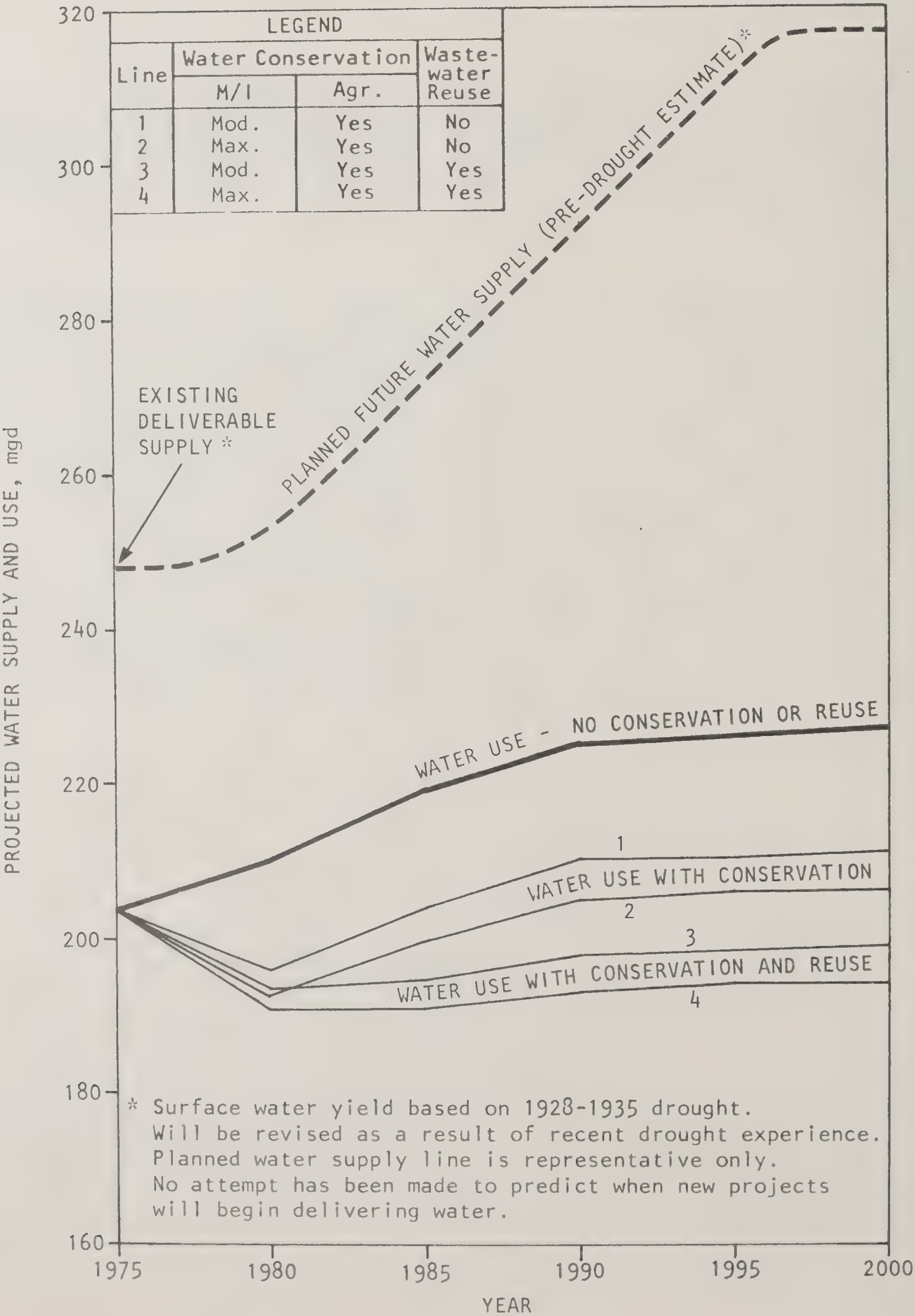
The nature and extent of water supply currently available to the Bay Area have been presented in Chapter II. Current water supply to the Bay Area is approximately 1,590 mgd for municipal and agricultural purposes. These present sources, if fully utilized, could deliver approximately 1,860 mgd. This amount is based upon withdrawing from surface water supplies the average available annual yield, based on the 1928-1935 drought, and the annual safe yield from groundwater basins. This groundwater safe yield is the total of natural plus artificially recharged groundwater. Under these conditions the Bay Area had, in 1975, an apparent reserve total supply capacity of 280 mgd, or 18 percent of the 1975 water use. Because the apparent reserve in 1975 was a result of water supply planning, it is assumed in the subsequent analysis of water supply and water use that a 15 to 20 percent reserve above the water-use projection is a reasonable goal. The lower figure might apply to an area that has groundwater available in significant quantities and the higher percentage would be more appropriate for an area totally dependent upon surface water. Actual percentages used in water supply system design should be determined on a case-by-case basis by each water utility.

The drought of 1976-1977 complicated the analysis of supply and projected water use which, of necessity, was made for this study prior to the end of the drought. At the end of the drought probably all surface water yields in California will be revised. This will be done by estimating the maximum annual yield that could have been obtained during the dry years and will depend upon the amount of carry-over storage available and the annual runoff into the reservoir. In Marin County the Marin Municipal Water District estimated in May 1977 that if the 1977-1978 water year were to have normal rainfall, i.e., an end of the drought, their surface supplies would have delivered 74 percent of the prior estimate of reservoir yields which had been based upon the 1928-1935 drought. Although this 26 percent reduction in safe yield is only an estimate for one water agency in the Bay Area and not necessarily agreed to by other agencies, it was the only information currently available. Consequently it was used in this study to assess the impact of a reduction in safe yields on

future water supply planning. Other water agencies found mandatory rationing necessary due to reduced safe yields, cut-backs in State and Federal project water deliveries, rapidly declining groundwater tables, etc. After the drought is over this analysis of future water supply needs in the Bay Area should be reviewed and consideration given to the alternative of mandatory water rationing during future droughts.

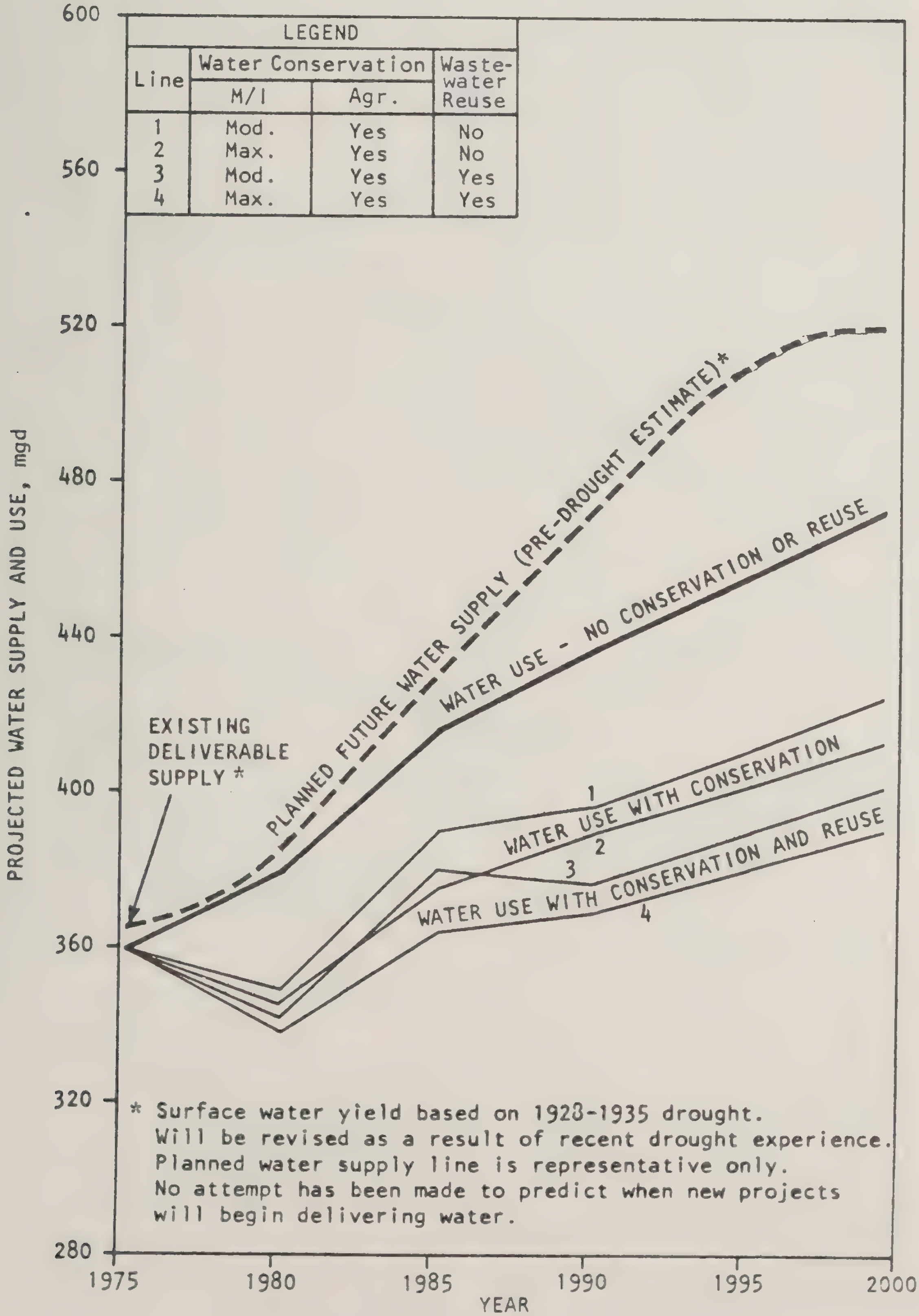
Water supply and projected water use curves through the year 2000 for the five subregions in the Bay Area and the entire Bay Region are presented on Figures VI-1 through VI-6. Figure VI-7 shows the impact on the Bay Region of reducing surface water yields by 26 percent. All the curves were developed in a similar manner. The upper line, planned future water supply, shows the present rated capacity of sources now in use in the Bay Area and assumes by the year 2000 that all projects listed in Chapter II serving the subregion will be built. Some may be built sooner, others later than 2000. In cases where a supply serves more than one subregion, as in the case of the Hetch Hetchy system, the additional supply to each subregion has been allocated in proportion to the water used from this source in 1975. The existing deliverable supply represents an estimate of how much could be actually obtained from all sources currently developed without building any new reservoirs, aqueducts, or water treatment plants. These two supply quantities have been tabulated by source in Table II-4.

Three different projected water use curves are shown. The higher curve is the combined municipal and agricultural water use without water conservation. The curve denoted "1" assumes a moderate level of municipal water conservation (Alternative 2) and agricultural water conservation. The curve denoted "2" replaces Alternative 2 with a reasonable maximum level of municipal conservation (Alternative 7) combined with agricultural conservation. For the entire Bay Region, Alternative 2 would save 8.8 percent of the municipal water use without conservation in year 2000, and Alternative 7 would save 11.4 percent. The water savings for agricultural water conservation would be approximately 15.4 percent of the water use in 1980, increasing to 18 percent in year 2000 due to a projected decline in irrigation water requirements. The two water-use curves shown for wastewater reuse (3 and 4) are based upon deducting the equivalent water savings shown in Table V-7 for reuse from the two water-use curves with water conservation. The vertical scale on Figures VI-1 through VI-7 has been expanded to emphasize the differences between the five water use curves.



PENINSULA SUBREGION
SAN FRANCISCO AND SAN MATEO COUNTIES
PROJECTED WATER USE AND ESTIMATE OF WATER SUPPLY

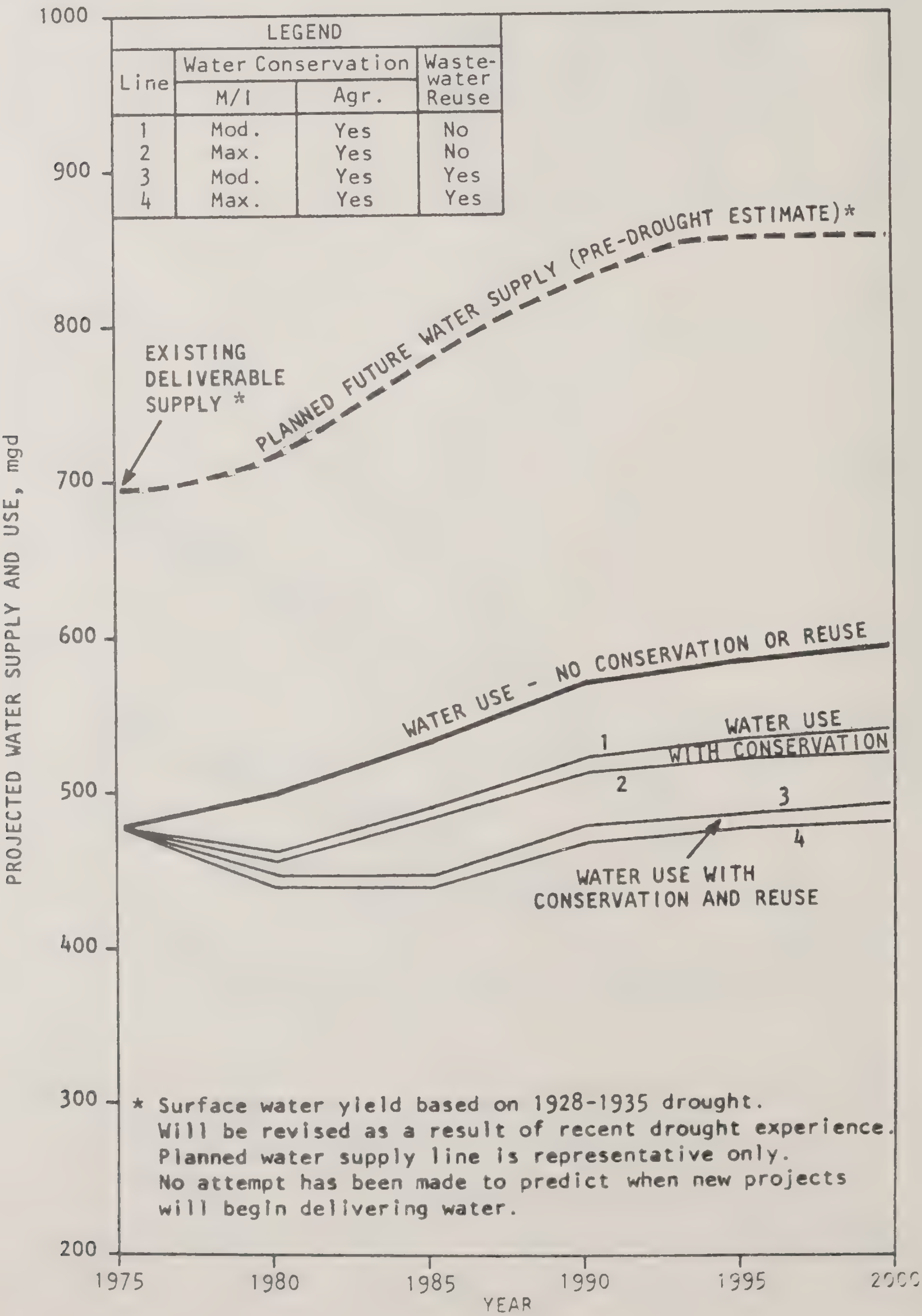
JBGA/WOM/RTC 7/77 FIGURE VI-1



SOUTH BAY SUBREGION
SANTA CLARA COUNTY
PROJECTED WATER USE AND ESTIMATE OF WATER SUPPLY

JBGA/WOM/RTC 7/77

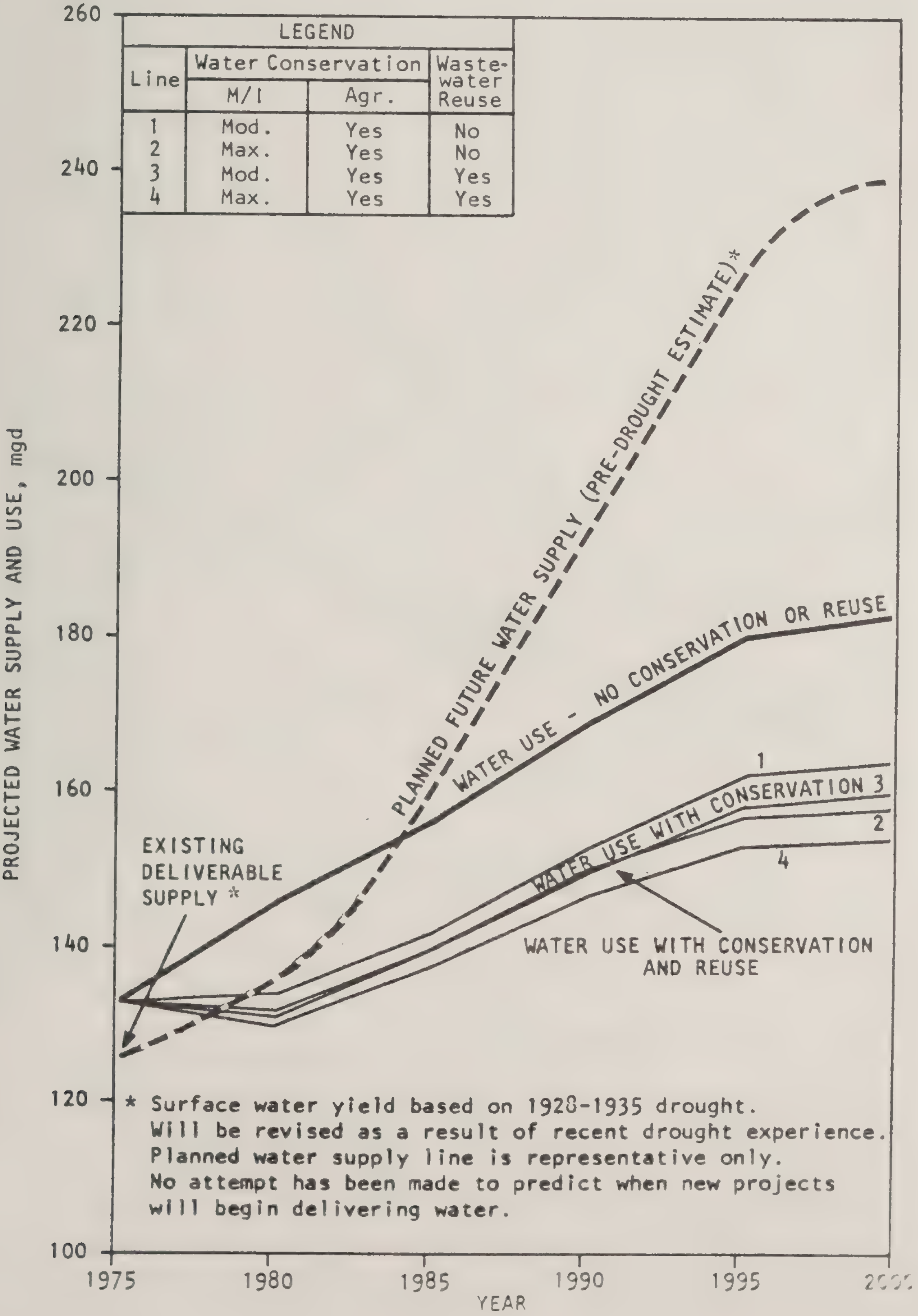
FIGURE VI-2



EAST BAY SUBREGION
ALAMEDA AND CONTRA COSTA COUNTIES
PROJECTED WATER USE AND ESTIMATE OF WATER SUPPLY

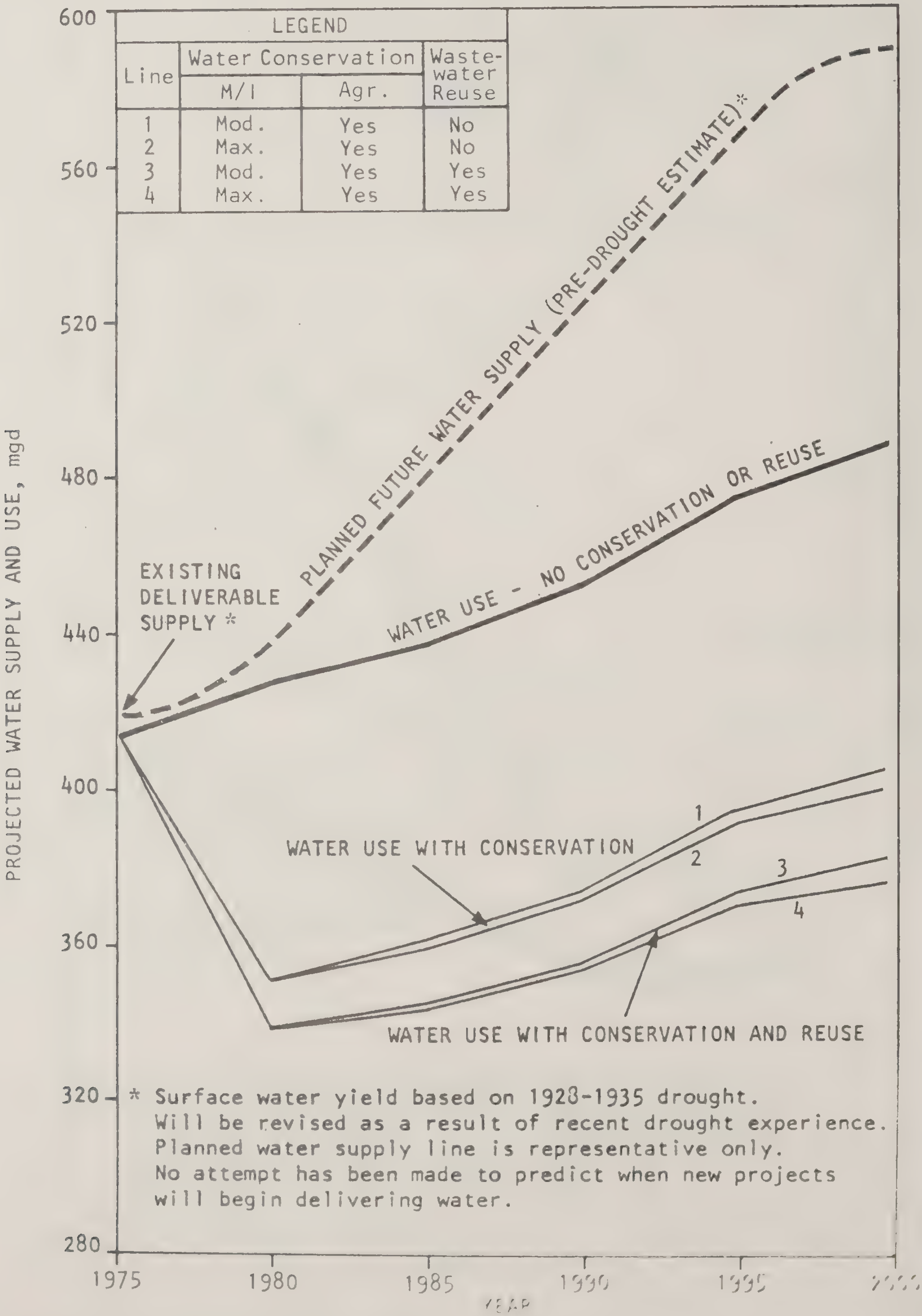
JBGA/WOM/RTC 7/77

FIGURE VI-3



MARIN AND SONOMA SUBREGION
MARIN AND SONOMA COUNTIES
PROJECTED WATER USE AND ESTIMATE OF WATER SUPPLY

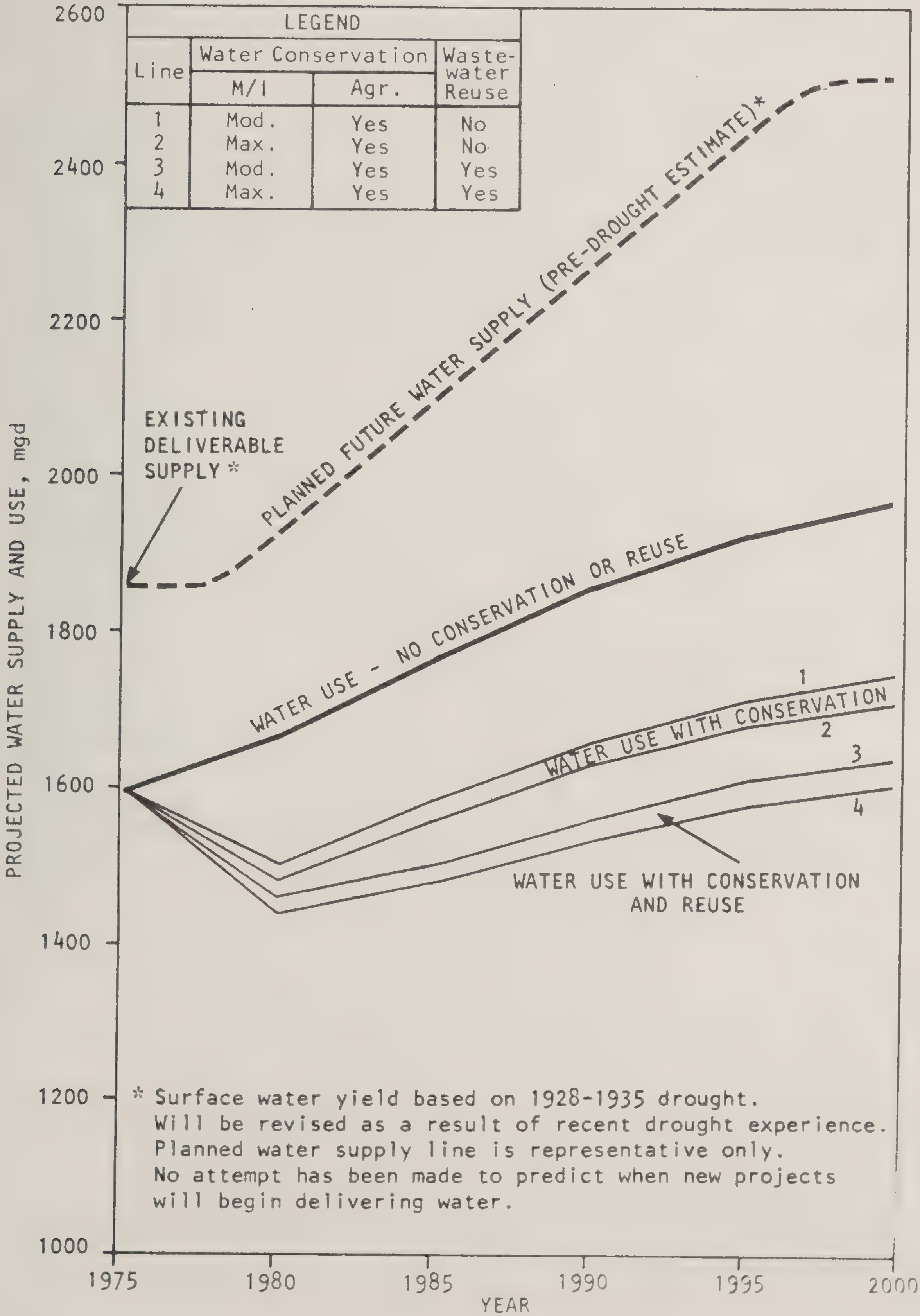
JBGA/WOM/RTC 7/77 FIGURE VI-4



NAPA AND SOLANO SUBREGION
NAPA AND SOLANO COUNTIES
PROJECTED WATER USE AND ESTIMATE OF WATER SUPPLY

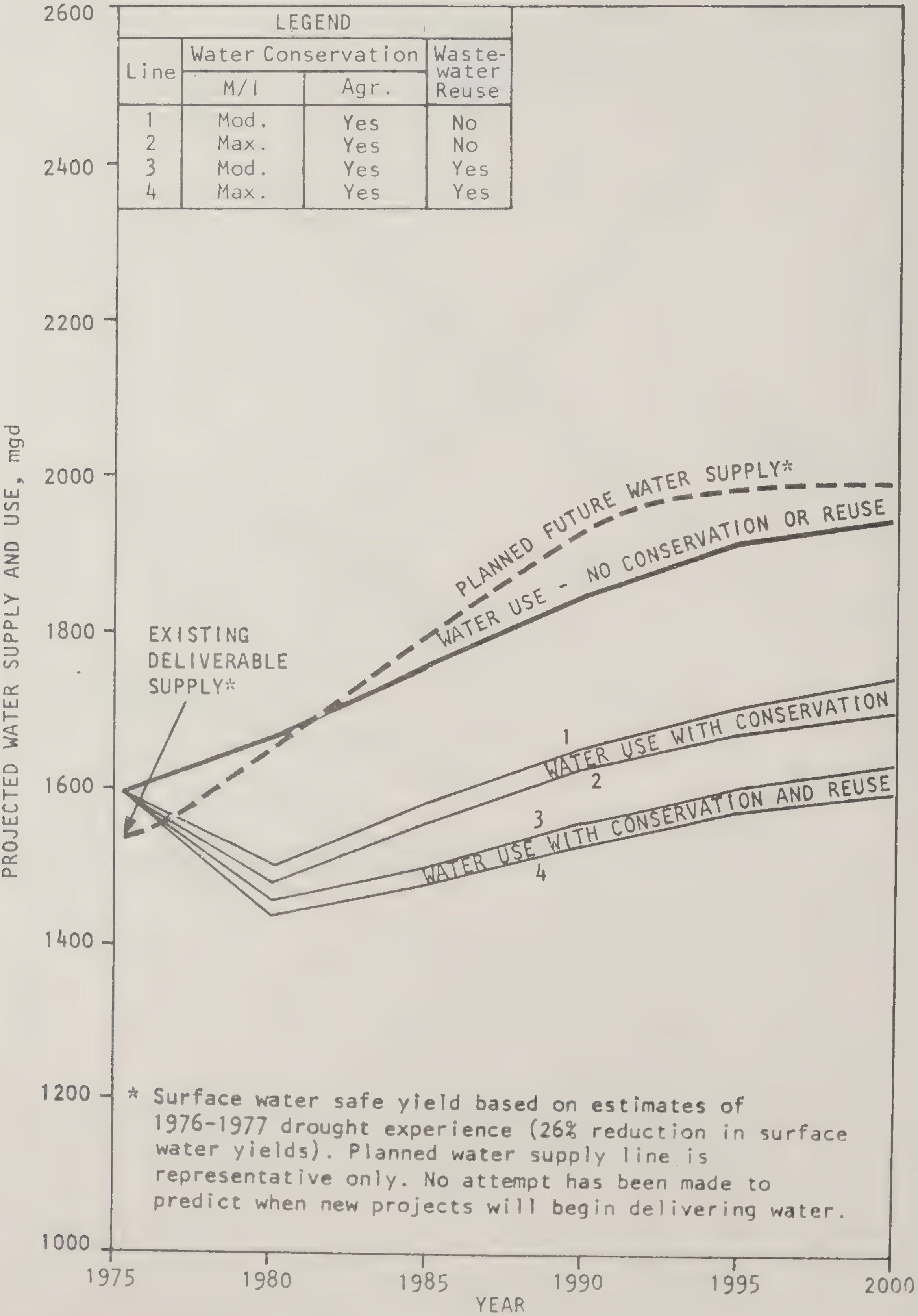
JBGA/WOM/RTC 7/77

FIGURE VI-5



BAY REGION
PROJECTED WATER USE AND ESTIMATE OF WATER SUPPLY
JBGA/WOM/RTC 7/77

FIGURE VI-6



BAY REGION
PROJECTED WATER USE
AND REVISED ESTIMATE OF WATER SUPPLY

JBGA/WOM/RTC 7/77

FIGURE VI-7

It was estimated in Chapter V that fully implementing reuse in the Bay Region would save 108 mgd of fresh water by the year 2000. This would reduce total water use in year 2000 by 5.5 percent.

The following discussion highlights the effects of water conservation on water use and the water supply reserve capacity at the subregional level. Percentages referred to in the following text with respect to reserve capacity or shortages are referenced to the no conservation, no reuse base water-use projections.

Water Supply and Use in the Peninsula Subregion. Based on the estimates of existing deliverable supply, the Peninsula subregion currently (1975) has a reserve capacity (above actual water use) of 22 percent, as shown on Figure VI-1. By the year 2000 this reserve above the no conservation or reuse projection would decline to nine percent. A moderate level of water conservation (Alternative 2) would result in a reserve of 15 percent in the year 2000. Construction of the fourth barrel of the Hetch Hetchy Aqueduct and allocating another 69 mgd to these two counties would provide a reserve in the year 2000 of 40 percent over the no conservation case.

If, after the effects of the 1976-1977 drought are evaluated, the surface water yields are only 74 percent of that previously assumed, then the existing deliverable supply would be 21 percent below the base water use in year 2000 and four percent below demand with maximum conservation and wastewater reuse. Construction of the fourth barrel of the Hetch Hetchy Aqueduct under these revised yield assumptions would add 51 mgd and provide a five percent reserve over the base water use. Under these assumptions a moderate level of conservation and wastewater reuse would be needed in addition to this new supply project to produce a reserve supply of 15 percent.

Water Supply and Use in the South Bay Subregion. As shown on Figure VI-2, the South Bay subregion currently has a negligible reserve supply. This has been acceptable because groundwater provides half the water supply and groundwater safe yields can be overdrawn in times of drought and recharged in wet years. As the South Bay subregion begins to rely more on surface water, a higher reserve may be needed. After the San Felipe project is completed and assuming an additional 20 mgd from expansion of the Hetch Hetchy Aqueduct, the South Bay subregion will have a supply of approximately 510 mgd, which will be about seven percent above the no conservation or no reuse

water use curve in year 2000. Moderate water conservation (Alternative 2) would provide a reserve of 20 percent. It should be noted that water use is still growing rapidly in the year 2000 and this reserve will be declining after year 2000.

However, if all planned projects are built but surface water yields are reduced by 26 percent, the South Bay subregion will face a potential shortage between 1985 and 1990, growing to an 11 percent shortage by the year 2000. Under these conditions a combination of maximum conservation plus reuse would be needed to provide a reserve of eight percent.

Water Supply and Use in the East Bay Subregion. As shown on Figure VI-3, the East Bay subregion had a reserve of 45 percent in 1975. By the year 2000 several planned sources of water, principally the American River project, will be able to maintain the current reserve at approximately the same level without conservation or reuse.

However, if surface water yields are reduced 26 percent, these additional planned sources of water would provide a reserve of only nine percent without conservation or reuse. Under this assumption, and without these projects, a potential shortage would develop between 1985 and 1990. Maximum conservation (Alternative 7) plus reuse would achieve a 35 percent reserve in the year 2000, a value more comparable to the 1975 reserve capacity.

Water Supply and Use in the Marin-Sonoma Subregion. As shown on Figure VI-4, the Marin-Sonoma subregion was facing a potential water shortage of five percent in 1975. They were able to meet use because of wet years. A major new project, the Warm Springs Dam, is planned and would provide a 31 percent reserve in the year 2000 over the no conservation case, provided the supply was distributed throughout the subregion.

If the existing deliverable supply is reduced to 74 percent of the previous estimate, the 1975 five percent potential water shortage will increase to 40 percent by the year 2000 without conservation or reuse. The total reserve including that provided by the Warm Springs Dam project would be reduced to eight percent. Implementation of moderate conservation (Alternative 2) would provide a 20 percent reserve, and implementation of maximum conservation (Alternative 7) plus

reuse would provide a 28 percent reserve for these revised supply yield conditions.

Water Supply and Use in the Napa-Solano Subregion. Currently the Napa-Solano subregion has a very small reserve, on the order of two percent. Referring to Figure VI-5, by the year 2000, without conservation and reuse and without importing new water supplies, this subregion will have a potential water shortage of 14 percent in the year 2000. Moderate water conservation, principally agricultural water conservation in Solano County, would provide a three percent reserve in the year 2000. Maximum water conservation plus reuse would provide a 10 percent reserve in the year 2000 over the existing deliverable supply. If both the North Bay Aqueduct and the West Sacramento Valley Canal are built, the supply situation, particularly in Solano County, would be much better in the year 2000, with a reserve of 21 percent for the subregion over the base water use. Moderate water conservation would increase this reserve to 41 percent. It should be noted that in the year 2000, water use would still be growing rapidly and this reserve would decrease after year 2000.

If the amount of water that the Napa-Solano subregion can get from its surface supplies is reduced by 26 percent, even the construction of both of these projects will still leave a three percent potential shortage in the year 2000 without conservation. Without these projects and under these assumptions, even maximum conservation and reuse will fall short by eight percent in the year 2000. If only the North Bay Aqueduct is built as planned, but all surface yields are reduced, the subregion would face a 31 percent potential shortage without conservation and an 11 percent shortage with maximum conservation and reuse.

This water use and supply analysis assumes that if the West Sacramento Valley Canal were built, it would not be used to serve new irrigated acreage. Probably, for the project to be justified, it would bring new acreage under irrigation, rather than be put into a reserve capacity status. Consequently, demands for water would rise and without water conservation the Napa-Solano subregion would continue to operate with virtually no reserve.

Water Supply and Use in the Bay Region. As shown on Figure VI-6, the Bay Region has an apparent 18 percent reserve. However, the subregional analysis indicated that these

individual reserves ranged from minus five percent to 45 percent. By the year 2000 this reserve could grow to 29 percent if all projects were built. Moderate water conservation would increase this reserve to 46 percent. By the year 2000 all subregions will have a reserve, some more than others, so that this apparent reserve is not applicable to all areas.

Applying the reduced surface water yield criteria, i.e., a 26 percent reduction in pre-1976 drought estimates, the balance of water supply and water use in the Bay Region becomes quite critical, as shown in Figure VI-7. Overall, in 1975 the Bay Region faced a four percent shortage. Without conservation this shortage would grow to 22 percent by the year 2000. Even if all projects were built, the reserve for the Bay Region would be only two percent. If water supplies are not transferrable from one subregion to another, two out of the five subregions would face a potential shortage in year 2000 and the other three would have reserves of less than 10 percent. If all projects were built, moderate water conservation would provide a 15 percent reserve in the year 2000; moderate conservation plus reuse would provide a 20 percent reserve; and maximum conservation plus reuse would provide a 25 percent reserve.

Air Quality

There are no direct impacts of water conservation, reuse, and supply on air quality. Water supply could indirectly affect urban development, which could cause some change in air quality. These situations would be due to a restricted water supply and an associated imposition of a water conservation ban. These effects are usually only temporary, such as in times of drought.

Physical Resources

Implementation of proposed reclamation and reuse projects will have an indirect effect on the amount of land devoted to agricultural uses. It is estimated that 32 percent of reuse in the Bay Area will be used by agriculture. While many of the reuse projects proposed for the Bay Region will supply water to lands already in agricultural use, implementation of projects such as the year-round reclamation and reuse project in Sonoma Valley will allow additional lands to be used for pasture or other agricultural uses. Although the total amount of new agricultural

lands made available through these projects will be minimal, reuse will help agriculture in the Bay Region remain viable by converting, in most cases, presently dry-farmed land to more productive irrigated cropland.

Energy

Implementation of water conservation will reduce requirements for energy. In the home, changes in habit and such devices as shower-flow restrictors and insulated hot-water pipes will reduce heated water requirements. Reduced water consumption will require less water development, conveyance, treatment, and distribution. All of these activities consume large amounts of energy. A 10 percent reduction in water use would probably result in a five to 10 percent reduction in energy usage. After the current 1976-1977 drought is over, the effects of water rationing on energy usage will be better known.

Implementation of reuse projects would require energy for processing and transport. Estimates of energy required for operation of a 5.0 mgd reclamation plant indicate that approximately 360,000 kilowatt-hours of electrical energy would be consumed during operation of the plant on a six-month basis. However, if this is replacing another source of water supply, this energy usage would partially offset energy required to develop, treat, and deliver the normal water supply. For the Bay Region, full implementation of reuse would cause energy usage to increase an insignificant amount.

Construction of new water supply projects consume large amounts of energy. Developing and importing water supplies to the Bay Area also requires energy, as does treatment and distribution of the supply. Elimination of any of these projects would result in reduced energy usage.

Amenities

Development of proposed water supply sources could have direct impact on the natural environment. Impacts related to these projects have been addressed in environmental assessment documents prepared for these projects. Agricultural reuse projects increase productivity of land over dry-farming. There are other amenities associated with preserving agriculture in the Bay Area, such as providing aesthetic value, visual enjoyment, and permanent open space.

SOCIAL ASSESSMENT

An overall evaluation of the social impacts of water conservation, reuse, and supply was made. The following sections address social impacts on housing supply, health and safety, sense of community, equity, and urban patterns.

Housing Supply

Retrofitting of water-saving devices, such as toilet-tank displacement bottles and shower flow-control inserts, would have a minimal impact on the cost and rental of existing housing stock. As indicated later in this chapter under the discussion on economic impacts, cost per household for these devices is estimated at $1.

Implementation of a program which requires that water-saving devices be installed in new homes would have a direct impact on the cost of new housing units. Water-saving devices, which include low-flush toilets, shower and faucet flow controls, shower head cut-off valves, mixing valves on sinks, and hot-water pipe insulation, would cost individual homeowners over $300 for the maximum conservation program. If the cost to apartments is amortized along with the construction cost, the impact would translate to a monthly cost increase of $1 to $2. At current water and energy rates, approximately $1 per month would be saved on utility bills. Consequently, homeowner net costs or rent prices should increase no more than $1 per month under the maximum conservation program and less than $1 for the moderate conservation program.

Implementation of additional water supply projects for the Bay Area would have a direct effect on future housing supply. Current drought conditions have resulted in the issuance of a local building ban in one area where citizens have voted to limit development of future water supplies (viz., part of Marin County). In other areas, it is possible that current growth trends could continue without implementation of new water supply projects.

Health and Safety

Specific treatment level requirements for various uses of reclaimed water have been outlined in Chapter V. These

guidelines were designed to minimize short-term and long-term impacts on public health associated with implementation of these projects. Agricultural and landscape irrigation reuse projects planned for the Bay Region are designed to comply with State regulations; consequently, there should be no negative effects of these projects.

Sense of Community

Implementation of any level of water conservation program will have an overall effect on individual and communitywide patterns of living in that they tend to reinforce the reality that the earth's physical resources are finite and that conservation, voluntary or mandatory, will become a way of life.

Public education programs designed to convey information regarding water conservation measures would be instrumental in eliciting communitywide support for voluntary conservation measures, as well as mandatory water rationing plans.

Equity

Implementation of the retrofit program for existing homes, which calls for voluntary installation of toilet-tank bottles and low-flow shower head inserts, will have a minimal impact on current living patterns. Requiring installation of water-saving devices in new homes will have a direct impact on the cost of new housing. As indicated in the discussion on economic impacts, direct and indirect costs would range from $30 under the moderate plan to $355 under the maximum plan. Although the increased costs associated with alternatives involving either moderate or maximum implementation of water-saving devices would represent a larger proportion of total cost in lower priced housing stock, the overall impact on housing costs would be minimal (less than one percent of a $50,000 home under the maximum conservation plan).

The agricultural water conservation plan, if only implemented in the Bay Area counties, may appear to be inequitable. In the long-term, agricultural water conservation is expected to pay dividends to the farmers in reduced water cost and labor cost. However, implementation costs to individual farmers or irrigation districts participating in this plan may put them at an initial disadvantage in competing with those farmers elsewhere in the State who grow the same crops but are not required to make the capital investments necessary to conserve water. Therefore, in order to be

totally equitable, it would be best to implement such a program on a statewide basis.

Urban Development Patterns

Implementation of water conservation and reuse programs would in effect increase the existing water supply in most Bay Area counties, allowing water distribution agencies to more easily accommodate future growth of urban development. People, however, usually locate their home irrespective of available water supplies and most frequently without an analysis of historic water development and the security of the water supply. Urban and rural development patterns, including the type of new developments, as well as the proposed density and timing of development, would continue to be regulated by local planning policy. In the coming years, ABAG, water utilities, and the residents of the Bay Area should give thought to the extent to which water supply systems should be cooperatively managed to assure the most efficient use of the supplies available to the region and to prevent local adverse effects of drought or other emergency conditions.

ECONOMIC ASSESSMENT

Elements of the water conservation, reuse, and supply plan involve large capital expenditures of money and substantial ongoing operation and maintenance costs. To make an assessment of how the Bay Area should cope with increasing demands for water, it is convenient to consider water conservation, reuse, and new water source development as three alternatives of new water supply. For this consideration, it is useful to compare costs on a uniform basis. The unit cost of water, expressed in terms of $/acre-ft or ¢/kgal, was selected for this study. From a cost-effectiveness standpoint, a given subregion in the Bay Area should develop the source of water which has the lowest unit cost, then develop the source with the next lowest unit cost, and so forth until sufficient water has been provided to meet present and projected water needs.

Unit Costs of Water Conservation, Reuse, and Supply

Unit costs of new water supplies available to the Bay Area have been presented in Table II-10. The costs, which do not include treatment, distribution, and utility administration but do include

water source development or purchase and conveyance to the Bay Area, ranged from 10.4 ¢/kgal to 29.7 ¢/kgal. Costs of distributing the water are not dependent upon source development and should not be included. Cost of water treatment will vary depending upon source water quality and existing capacity or ease of expansion of treatment plants. Incremental administrative costs are expected to be minor. For comparison, the average unit cost of water supply in the Bay Area from the 20 largest water utilities, which includes not only the water source development or water purchase and conveyance to the Bay Area but also water treatment and distribution and utility administration, was 46.5 ¢/kgal in 1975. Present water rates will most certainly increase if new supplies are imported. For example, East Bay Municipal Utility District has estimated that their existing water supply from the Mokelumne River costs about 8.4 ¢/kgal whereas water supplied by the American River project would cost 29.7 ¢/kgal. In this case, for water conservation and reuse to be cost-effective (as defined in this study), it would have to cost less than 29.7 ¢/kgal.

Costs to implement the moderate and maximum municipal water conservation plan on a per-dwelling-unit basis have been presented in Chapter III. Using the projected increase in single and multiple dwelling units developed by ABAG in their Provisional Series 3 Base Case 1 Projections, the costs to install water-saving devices in new construction in five-year increments were developed as well as the costs for the retrofit program. The costs for implementing the moderate water conservation plan are shown in Table VI-1. Costs for implementing the maximum plan are over ten times more, as shown in Table VI-2. As shown in Tables VI-3 and VI-4, the costs for the two water conservation plans, when averaged over the 25-year implementation period, are substantially less than the total capital costs. The unit costs for the moderate plan range from 2.3 to 5.3 ¢/kgal and average 3.7 ¢/kgal for the Bay Region. Unit costs are higher than average in those areas anticipated to have a relatively high proportion of new dwelling units over the next 25 years. Unit costs for the maximum plan shown in Table VI-4 average 30 ¢/kgal and range from 15.8 ¢/kgal in a slowly growing subregion (Peninsula) to 43.7 ¢/kgal in a relatively rapidly growing subregion (Napa-Solano).

Costs of agricultural water conservation are summarized in Table VI-5. The capital costs and water savings have been developed in Chapter III. The annual cost was obtained by amortizing the capital cost at the rate of 6-3/8 percent for 23 years. Increased

TABLE VI-1

ESTIMATED COST OF WATER CONSERVATION IN BAY AREA
FOR MODERATE IMPLEMENTATION OF SELECTED DEVICES
(10^3 dollars, 1977)

County	Retrofit*	New Construction					
		1975-80	1980-85	1985-90	1990-95	1995-2000	Total
Alameda	396.7	1,301.6	1,181.6	1,073.5	432.0	439.0	4,824.4
Contra Costa	201.7	1,052.6	1,101.5	1,040.4	551.3	454.8	4,402.3
Marin	79.2	331.6	289.0	531.2	353.6	163.9	1,748.5
Napa	28.4	44.4	30.8	45.9	72.1	220.8	442.4
San Francisco	299.3	235.3	14.1	98.7	103.8	104.9	856.1
San Mateo	208.1	483.8	533.9	482.4	65.9	68.5	1,842.6
Santa Clara	392.4	1,697.4	2,054.7	1,647.3	1,453.7	1,766.4	9,011.9
Solano	62.3	413.7	353.4	444.0	907.0	716.2	2,896.6
Sonoma	100.5	602.0	399.0	375.7	494.7	448.6	2,420.5
Bay Region	1,768.6	5,162.4	5,958.0	5,739.1	4,434.1	4,383.1	28,445.3

*Based on dwelling units existing in 1975

TABLE VI-2

ESTIMATED COST OF WATER CONSERVATION IN BAY AREA
FOR MAXIMUM IMPLEMENTATION OF SELECTED DEVICES
(10^3 dollars, 1977)

County	Retrofit*	New Construction					
		1975-80	1980-85	1985-90	1990-95	1995-2000	Total
Alameda	396.7	13,954.9	13,001.9	11,574.4	4,405.1	4,863.9	48,196.9
Contra Costa	201.7	11,586.8	12,270.0	11,613.3	6,113.6	5,127.8	46,913.2
Marin	79.2	3,638.5	3,161.1	5,918.8	3,915.6	1,840.4	18,553.6
Napa	28.4	451.3	316.5	488.2	771.6	2,498.1	4,554.1
San Francisco	299.3	2,394.8	143.4	1,004.7	1,062.0	1,122.6	6,026.8
San Mateo	208.1	5,225.0	5,855.9	5,307.0	714.4	769.6	18,080.0
Santa Clara	392.4	18,577.1	22,816.4	18,548.3	16,497.9	19,814.9	96,647.0
Solano	62.3	4,467.8	4,137.9	4,930.0	10,226.0	8,064.2	31,888.2
Sonoma	100.5	6,529.9	4,326.8	4,095.3	5,423.3	5,043.2	25,519.0
Bay Region	1,768.6	66,826.1	66,029.9	63,480.0	49,129.5	49,144.7	296,378.8

*Based on dwelling units existing in 1975

TABLE VI-3

COST AND WATER SAVED, 1975-2000, FOR
MODERATE IMPLEMENTATION OF SELECTED DEVICES
(1977 dollars)

Subregion	Water Saved* mgd	Total Cost 10^3 $	Average Annual Cost* 10^3 $	Unit Cost of Conservation	
				$/acre-ft	¢/kgal
Peninsula	13.2	2,698.7	107.9	7.33	2.3
South Bay	24.9	9,011.9	360.5	12.93	4.0
East Bay	30.6	9,226.7	369.1	10.75	3.0
Marin-Sonoma	8.7	4,169.0	166.8	17.15	5.3
Napa-Solano	7.0	3,339.0	133.6	16.91	5.2
Bay Region	84.4	28,445.3	1,137.9	12.03	3.7

*Average for the years 1975 through 2000.

operational costs are assumed to be offset by reduced water and labor costs. Unit costs range from 13.3 to 25.1 ¢/kgal and average 15.6 ¢/kgal. This is approximately three to four times the present cost of agricultural water in the Bay Area. If the program were implemented statewide and subsidies were made available, unit costs could be reduced.

Costs of reuse, on a project-by-project basis, have been presented in Table V-6. Costs include treatment above that required for disposal and distribution but exclude administration over and above operation and maintenance of the reuse project. Some of the projects listed would not generate new water supply, and these were not assessed from a cost-effective standpoint. Six projects were less than totally effective in providing an equivalent amount of water supply. These savings ranged from 50 to 90 percent of the total annual reuse. These projects were located in the following areas: Northern Bay Shore cities; Union Sanitary District; Central Contra Costa; Sonoma Valley; Napa-

TABLE VI-4

COST AND WATER SAVED, 1975-2000, FOR
MAXIMUM IMPLEMENTATION OF SELECTED DEVICES
(1977 dollars)

Subregion	Water Saved* mgd	Total Cost 10^3 $	Average Annual Cost* 10^3 $	Unit Cost of Conservation	
				$/acre-ft	¢/kgal
Peninsula	16.8	24,106.8	964.3	51.38	15.8
South Bay	31.0	96,647.0	3,865.9	111.37	34.2
East Bay	39.4	95,110.1	3,804.4	86.14	26.4
Marin-Sonoma	12.0	44,072.6	1,762.9	131.16	40.3
Napa-Solano	9.1	36,442.6	1,457.7	142.39	43.7
Bay Region	108.3	296,378.8	11,855.2	97.71	30.0

*Average for the years 1975 through 2000.

Carneros; and Fairfield-Suisun. Unit costs for all projects are expressed in terms of ¢/kgal of reclaimed wastewater. Unit costs for these six projects would be higher if expressed on the basis of fresh water saved.

Cost-effectiveness of Water Conservation, Reuse, and Supply

The unit costs of moderate municipal water conservation (Alternative 2), maximum municipal water conservation (Alternative 7), agricultural water conservation, all reuse projects effective in saving water, and all new major water supply projects are tabulated, by subregion, in Table VI-6. For each subregion, projects are listed and ranked in increasing order of unit cost. Rankings for each of the 40 projects within the entire Bay Region are also presented. The first numerical ranking in each column is based upon the total unit cost of the project at full capacity without any State or Federal assistance. The second ranking in

TABLE VI-5

UNIT COSTS OF AGRICULTURAL WATER
CONSERVATION BY SUBREGION
(1977 dollars)

Subregion	Water Saved acre-ft/yr	Capital Cost	Annual Cost	Unit Cost	
				\$/acre-ft	¢/kgal
Peninsula	500	335,000	30,100	63.8	19.6
South Bay	13,000	8,400,000	755,200	58.1	17.8
East Bay	12,150	5,860,000	526,800	43.4	13.3
Marin-Sonoma	6,150	5,590,000	502,600	81.7	25.1
Napa-Solano	79,500	42,625,000	3,832,000	48.2	14.8
Bay Region	111,300	62,810,000	5,646,700	50.7	15.6

parentheses assumes that each reuse project receives State or Federal grants representing 87-1/2 percent of the construction costs. The impact of these grants has been evaluated on a subregional basis. For the overall Bay Region the unit costs of reuse with grants would be reduced to 40 percent of the unit cost without assistance. In many cases this has a dramatic effect on the rankings, moving reuse from the bottom of the list to near the top. Because these unit costs are only estimates, small differences in unit costs (± 20 percent) should not be interpreted as significant. Unit costs throughout each subregion vary by a factor of about 10 to 20 times. Cost differences among alternatives of 100 percent are common and are interpreted in this study to be significant differences in cost-effectiveness. The purpose of the following discussion is to assemble all alternatives within each subregion into priority groups based upon similar cost-effectiveness. It should be noted that some of these projects, such as moderate water conservation and certain water supply projects, are in the process of being implemented. The reader is referred to the section on water supply and use earlier in this chapter for an analysis of how much additional water supply is needed in each subregion.

TABLE VI-6

COST EFFECTIVENESS OF WATER CONSERVATION, REUSE, AND NEW SUPPLIES

Ranking[a]		Type[b]			Project Name	Water Produced mgd	Unit Cost ¢/kgal
Within Subregion	Within Bay Region	C	R	S			
Peninsula							
1 (1)	1 (2)	x			Moderate Municipal	13.2	2.3
2 (3)	10 (17)			x	Hetch Hetchy	69.0	14.8
3 (5)	13 (21)	x			Maximum Municipal	16.8	15.8
4 (7)	16 (27)	x			Agriculture	0.5	19.6
5 (2)	22 (13)		x		San Francisco	2.0	26.7 (11.2)
6 (4)	26 (18)		x		North Bayside	6.0	35.2 (14.8)
7 (6)	32 (25)		x		Central Bayside	1.3	40.6 (17.1)
8 (8)	36 (29)		x		North Coastside and Pacifica	2.6	51.6 (21.7)
South Bay							
1 (2)	3 (4)	x			Moderate Municipal	24.9	4.0
2 (1)	7 (1)		x		Gilroy-Morgan Hill	7.2	6.5 (2.1)
3 (5)	10 (17)			x	Hetch Hetchy	20.0	14.8
4 (6)	14 (26)	x			Agriculture	11.6	17.8
5 (8)	18 (31)			x	San Felipe	134.0	24.0
6 (3)	22 (10)		x		Milpitas	1.9	29.3 (9.5)
7 (9)	25 (38)	x			Maximum Municipal	31.0	34.2
8 (4)	35 (16)		x		North Santa Clara County	6.9	45.1 (14.7)
9 (7)	39 (30)		x		Palo Alto	7.5	66.7 (21.7)
East Bay							
1 (1)	2 (3)	x			Moderate Municipal	30.6	3.3
2 (3)	9 (14)	x			Agriculture	10.9	13.3
3 (4)	10 (17)			x	Hetch Hetchy	11.0	14.8

TABLE VI-6
(Continued)

COST EFFECTIVENESS OF WATER CONSERVATION,
REUSE, AND NEW SUPPLIES

Ranking[a] Within Subregion	Within Bay Region	Type[b] C	R	S	Project Name	Water Produced mgd	Unit Cost ¢/kgal
East Bay (Cont.)							
4 (2)	19 (11)		x		Central Contra Costa	24.4	24.3 (9.5)
5 (8)	21 (34)	x			Maximum Municipal	39.4	26.4
6 (9)	24 (36)			x	American River	134.0	29.7
7 (5)	30 (20)		x		Livermore-Amador Valley	2.5	40.0 (15.6)
8 (6)	33 (22)		x		Union Sanitary District	5.5	41.9 (16.3)
9 (7)	38 (33)		x		San Leandro	1.5	65.6 (25.6)
10 (10)	40 (37)		x		Northern Bay Shore Cities	11.5	87.4 (34.1)
Marin-Sonoma							
1 (1)	5 (6)	x			Moderate Municipal	8.7	5.3
2 (3)	6 (12)			x	Warm Springs Dam	102.0	10.4
3 (2)	15 (8)		x		Sonoma Valley	1.7	18.2 (7.1)
4 (5)	20 (32)	x			Agriculture	5.5	25.1
5 (4)	28 (15)		x		South-Central Marin	0.6	35.6 (13.9)
6 (6)	31 (39)	x			Maximum Municipal	12.0	40.3
Napa-Solano							
1 (1)	4 (5)	x			Moderate Municipal	7.0	5.2
2 (2)	8 (7)		x		Fairfield-Suisun	12.0	12.2 (5.6)
3 (4)	11 (19)	x			Agriculture	71.0	14.8
4 (3)	12 (9)		x		Napa-Carneros	2.2	15.5 (7.1)
5 (7)	17 (28)			x	North Bay Aqueduct	55.0	21.1

TABLE VI-6
(Continued)

COST EFFECTIVENESS OF WATER CONSERVATION, REUSE, AND NEW SUPPLIES

Ranking[a]		Type[b]			Project Name	Water Produced mgd	Unit Cost ¢/kgal
Within Subregion	Within Bay Region	C	R	S			
Napa-Solano (Cont.)							
6 (5)	27 (23)		x		Vacaville	8.8	35.4 (16.3)
7 (6)	29 (24)		x		Calistoga	0.3	36.8 (16.9)
8 (9)	34 (40)	x			Maximum Municipal	9.1	43.7
9 (8)	37 (35)		x		Yountville	0.4	63.0 (29.0)

[a] Values listed in parentheses include Federal assistance

[b] Type of project: C, Conservation; R, Reuse; S, Supply

Peninsula Subregion. Moderate municipal water conservation is the least expensive option for the Peninsula subregion. After this the unit costs of maximum water conservation and the Hetch Hetchy expansion project are comparable and can be considered the second priority for developing new water supply. If reuse were grant eligible, it would also fall into this second priority group. If reuse is not grant eligible, only expansion of the Golden Gate Park reclamation plant would be equally cost-effective with water conservation and new source development.

South Bay Subregion. Moderate municipal water conservation is the least costly option in the South Bay, followed closely by a reuse project in Gilroy-Morgan Hill. The allocation of a portion of the Hetch Hetchy expansion project to the South Bay subregion would fall into the second priority grouping. The third priority grouping would contain the agricultural water conservation plan and the San Felipe project. It can be observed that only the San Felipe project could provide enough water to meet the subregion's future needs, as was shown in Figure VI-2. Reuse in this subregion would be comparable in unit cost to new source development only if reuse is grant eligible, otherwise it would be significantly more expensive. Maximum municipal water conservation is less cost-effective than other alternatives available to this subregion.

East Bay Subregion. Table VI-6 indicates that moderate water conservation should be the first priority in the East Bay subregion. The Hetch Hetchy expansion project, agricultural water conservation and the Central Contra Costa, Livermore-Amador Valley, and Union Sanitary District reuse projects would all be in the second priority grouping, but only if these projects were grant eligible. The third priority group would contain importation of American River water, maximum water conservation, and reuse in the San Leandro and Northern Bay Shore cities area, provided the latter two projects are grant eligible. If not grant eligible, all five reuse projects would have the lowest implementation priority.

Marin-Sonoma Subregion. As with the other subregions, moderate municipal water conservation has the highest priority. The second priority group would contain Warm Springs Dam project and reuse, if grant eligible. Agricultural water conservation is more expensive, principally due to the small scale. Maximum municipal water conservation would have the lowest priority.

Napa-Solano Subregion. Moderate municipal water conservation should be implemented first in this subregion together with reuse in the Fairfield-Suisun area and in the Napa-Carneros area if these two projects were grant eligible. Agricultural water conservation should be the second priority in the Napa-Solano subregion. Completion of the North Bay Aqueduct is the third priority. Also included in this priority group would be the other grant-eligible reuse projects.

As no refined cost estimate for the West Sacramento Valley Canal was available, its unit cost could not be considered. Maximum municipal water conservation and any grant-ineligible reuse projects would have the lowest priority in the Napa-Solano subregion.

Summary of Bay Region Cost-effectiveness. In all subregions the most cost-effective plan is the moderate municipal water conservation plan. Approximately six reuse projects, if grant eligible, also have a comparable unit cost to the moderate municipal water conservation plan. Except in the Marin-Sonoma subregion, the agricultural water conservation plan fell into the second priority grouping. Development of new sources of water supply follow the moderate municipal water conservation, agricultural water conservation, and selected grant-eligible reuse projects in three subregions; and in two subregions new source development unit costs were similar to agricultural water conservation and selected reuse projects. Reuse, generally, to be economically competitive with alternative sources of water supply, would require grant funding.

INSTITUTIONAL ARRANGEMENTS

Existing water and wastewater agencies, in general, have sufficient authority to implement water conservation and wastewater reclamation and reuse programs and to develop new sources of water supply. Only under mandatory water rationing would legislative, and perhaps major institutional, changes be required. The following discussion addresses possible institutional arrangements for the three elements of this plan which emphasizes better regional coordination of water conservation and the potential for water exchanges and wastewater reclamation.

To achieve better coordination, a new committee or group in the Bay Region should be formed. This committee would deal with

regional water and wastewater reuse activities and problems. The committee could be formalized by a joint powers agreement or it could act as an informal committee. Staff support could be provided by ABAG or the member agencies. Funding could come from State grants and the member agencies. The functions of the proposed committee, which could be called the Water Resource Management Coordinating Committee, are summarized in Table VI-7 and discussed in the following sections.

Implementation of Water Conservation Programs

From an institutional standpoint, the eight water conservation alternatives developed during this study fall into two groups. Alternatives 1, 2, 3, 6, 7, and 8 do not employ mandatory restrictions on water use whereas Alternatives 4 and 5 do.

For the following discussion the first set of alternatives are grouped into a plan called the likely water conservation program.

> Likely Water Conservation Program. A long-term public education program should be conducted in the Bay Region. It should capitalize on the substantial water savings realized during the summer of 1977. There should be included in the program newspaper specials, television programs, spot announcements, and a public reporting system for waste of water and common public fines, possibly for a second offense on wasteful use of water. The Water Resource Management Coordinating Committee could coordinate this effort and prepare a regular regional report on water supply activities. This effort should be directed and funded by the water agencies of the Bay Region. In the spring, special emphasis should be placed on lawn watering and the program could be accelerated if the weather conditions required more stringent measures. Other potential sources of funding would be State, either through the Resources Agency or the Department of Water Resources, which may require special legislation.
>
> The second part of this program deals with retrofitting existing dwellings with shower head and toilet-tank water conservation devices. This program is well underway in certain areas. It could be conducted by all Bay Region water utilities, as an extension of recently passed State legislation which authorizes expenditures for these devices. But most likely, this should be implemented by each water utility that has not yet undertaken this type of program.

TABLE VI-7

BAY AREA WATER AND WASTEWATER REUSE COORDINATION

Structure	Organization
Form	Joint Powers Agency or informal committee
Composition	Members: City and County of San Francisco Peninsula Water Agency Santa Clara Valley Water District South Bay Dischargers Alameda County Water District East Bay Municipal Utility District East Bay Dischargers Contra Costa County Water District Central Contra Costa Sanitary District Marin Municipal Water District Marin-Sonoma Wastewater Planning Agency Six rotating memberships of two years each selected at random from smaller districts Ex-Officio Members: Sonoma County Water Agency San Jose Water Works California Water Service Company State Water Resources Control Board Regional Water Quality Control Board State Health Department State Department of Water Resources U. S. Bureau of Reclamation U. S. Environmental Protection Agency U. S. Army Corps of Engineers
Staff Support	ABAG and/or local agencies
Functions	Drought information Conservation effectiveness reporting Water exchange discussions Reclamation project coordination Public information Coordination with land-use and population forecasts
Funding	Water utilities, wastewater agencies, and/or State grants

Building and plumbing codes should be revised by each city and county to provide for such devices in new construction, including insulating hot-water pipes, thermostatic mixing valves on certain lavatory and kitchen faucets, shower flow controls, and other devices listed in Chapter III corresponding to the selected (moderate or maximum) implementation plan. The Water Resource Management Coordinating Committee could provide assistance in these matters and a standard guide for retrofitting. The continuing planning process, as defined in the Environmental Management Plan, should provide for implementation of the recommended water conservation program and the request of each water utility to implement the retrofitting portion of the plan and of each city and county to adopt revised building and plumbing codes to implement the new construction portion of the plan.

Agricultural water conservation has been proposed at two levels. General improvements within each county and irrigation district dealing with reducing conveyance losses, monitoring soil moisture, and farmer education and applicable on-farm improvements involving the conversion of existing farms to more efficient methods of irrigation. To develop an equitable plan, this conservation program would have to be handled on a consistent statewide basis. New legislation will be needed mandating agricultural conservation. The role of counties, U. C. Agricultural Extension offices, and irrigation districts will be to continue their efforts in educating the farmers on the efficient use of water and in lining district canals where seepage losses are high. The Water Resource Management Coordinating Committee could represent the agricultural interests in the Bay Area if and when such legislation or other statewide agricultural conservation programs are proposed.

Mandatory Water Conservation. Water conservation alternatives 4 and 5, which entail 25 percent and up to 50 percent reductions in water use, respectively, would require mandatory restrictions on water use. This could be done through escalating rates or meter restrictions. The major problem in implementing this type of rationing is setting the policy of whether the rationing should be implemented on an agency-by-agency basis, or as it relates to the potential for water interchanges among major water supply agencies. If standby or regular interchanges are prearranged, the approach to water conservation should be common. If such interchanges are limited to a few agencies, those agencies should appropriately include mutual arrangements for water conservation.

If mandatory water conservation is to be undertaken on a long-term basis, in effect a permanent curtailment of the type experienced during 1977, State legislation would be needed together with a general approach in terms of enforcement and rates. In the absence of any prolonged drought, such State legislation is not likely to be successful. Also, depending upon the affected agency, the local residents probably would not accept water conservation unless there was a demonstrable need. Consequently, implementing mandatory water conservation is not a practical alternative from an institutional standpoint.

Implementation of Wastewater Reclamation

The Water Resources Management Coordinating Committee could assist in implementing wastewater reuse in the Bay Region. One of the committee's major objectives would be to provide regional coordination of reclamation projects where a single project may affect more than one agency. It could also be used to represent the Bay Region in dealing with the Legislature and the State Water Resources Control Board in reclamation projects that may have regional significance.

Reuse markets between the size of small local markets analyzed in this study and exports of large quantities of wastewater from the Bay Region probably exist but have never been developed into feasible reuse projects. Moreover, projects on a subregional scale have the advantages of lower unit costs for reclamation, higher reliability, and greater flexibility to serve new markets or a group of small markets that cannot be economically served by a series of small wastewater reclamation plants. One important function of the Water Resource Management Coordinating Committee would be to study the feasibility of these subregional markets. The local wastewater agencies would continue to be responsible for compliance with NPDES permit conditions and construction of wastewater treatment plants. However, in general, it would be desirable for the local water purveyor to be responsible for marketing (distributing) the reclaimed wastewater. Frequently users will only accept reclaimed wastewater if it is the only supply available for their intended use.

The only reason to form a new agency with authority to construct reuse projects in the Bay Region would be in the event that a regional reclamation program was to be implemented in the Bay Region. Such a program is the subject of an investigation

proposed by the Regional Water Quality Control Board and could lead to the export of large quantities of reclaimed water to the Central Valley for direct or blended use in existing irrigation systems. Implementation of this would require the formation of a joint powers or other type of entity among wastewater purveyors contributing wastewater to the regional system. The Water Resource Management Coordinating Committee would not have the appropriate authority to construct such a project but it could be the forerunner of such an agency if one were required.

As use of reclaimed wastewater increases, there will be greater need for health department surveillance of each project. An additional burden will fall upon local health departments and the State Health Department with respect to review during formulation of projects and surveillance during operation of facilities. The State Health Department should develop a statewide approach to the monitoring of reclaimed wastewater projects to assure that necessary safeguards are maintained.

Lack of agreement among the State Health Department, the Regional Water Quality Control Board, and the wastewater agency as to the required level of wastewater treatment prior to reuse can be expected to continue. In these cases, the Water Resource Management Coordinating Committee could offer assistance in resolving conflicts.

The Regional Water Quality Control Board provides strong leadership and statuatory authority in the field of water quality control, water quality planning, and enforcement. This study has identified a series of implementation programs that affect local water supply, wastewater, and land-use planning programs. It is essential that a partnership be developed between the Regional Board and ABAG so that the existing gap between land-use planning and water quality management can be bridged. This recommendation affects not only wastewater reclamation, but nonpoint source control, individual waste disposal, and a variety of other programs.

Implementation of Water Supply Development

New Source Development. The development of new water sources should continue to be the responsibility of individual water purveyors. It has been assumed that the San Felipe project, adding the fourth barrel of the Hetch Hetchy Aqueduct, the American River supply for EBMUD, and the final phase of the

North Bay Aqueduct will be implemented as well as the Warm Springs Dam in the Russian River area. This study has shown that these supplies, when coupled with reasonable water conservation, reclamation, and water exchanges can provide an adequate supply for the entire region for the foreseeable future. There may be isolated local areas of water problems, such as in western San Mateo and Marin counties and other small communities, but the principal areas can be effectively served through the suggested supply program.

Water Exchanges During a Drought. The Bay Region is, or will be, served by eight major water supply systems. This provides both a strength, in that the supply is diversified, and a weakness, in that the total supply is not available to all users. The recent drought has shown that there are advantages to water supply interchange agreements. Theoretically, the separate operations of the major water supply agencies is an impediment to coordinated regional supply providing more reliable service. In fact, most of these independent systems have resulted in the provision of reliable high-quality water and low cost.

The activities of the State Department of Water Resources during the recent drought give a good example of how a State and, in the future, perhaps a regional agency can aid in the resolution of drought-related problems and provide information on the current status of drought conditions. The Bay Region should have a drought-contingency plan for dealing with such emergencies, and the recent supply to Marin County which involved the EBMUD, State Department of Water Resources, and other water purveyors in the State, can serve as a model. The potential for major exchanges between the San Francisco and East Bay water systems, San Francisco and Santa Clara water systems, East Bay and North Bay and Contra Costa systems exists. Interchanges present some serious planning problems, however. An agency with an interchange agreement might use it as an excuse to delay otherwise needed water development, knowing that it could count on emergency supplies. There is presently an increased concern about the impact of growth of the Bay Region, especially in certain local areas, such as Santa Clara, Alameda, and the North Bay counties. Lack of water will serve as a constraint and indirectly affect growth patterns. Water supply planning should be coordinated with land-use planning at a local and at a regional level. Water supply should not be used, however, to control growth. A regional approach to water supply would have the advantage of

reducing costs, lessening impact on the environment, and minimizing adverse effects during a drought. ABAG could assist the Water Resource Management Coordinating Committee in negotiations and discussions leading to appropriate agreements between affected agencies. The possibility of State assistance for these programs and the long-term potential for grant assistance to allow local water utilities to meet the provisions of PL 92-523 will require a continued role of ABAG in cooperation with the State Department of Water Resources.

Water Exchanges During a Dry Year or Normal Year. Normally, each individual water supply system should provide adequate service during a dry year. The problem is that a dry year may be the forerunner of a drought and measures taken during a dry year, such as water exchanges and water conservation, can alleviate the long-term effects of a drought. The disadvantages of these exchanges would be that agencies might rely upon other agencies to carry them through a dry year. If such actions are planned for, there should be financial arrangements to assure that the participating agency pays for reduced costs of separate water supply development associated with dry-year exchanges.

There may be advantages for normal-year water exchanges to improve system operations, allow for supply system repairs, and cope with natural disasters, such as earthquakes. Advance planning between affected water agencies can reduce the impact of an emergency, improve service, and potentially reduce costs. The nature of separate agency operations tends to minimize consideration of water exchanges in normal years. Nevertheless, some common actions would be desirable.

FINANCIAL CONSIDERATIONS

Water Conservation

The cost of installing devices, in both existing and new construction, under the maximum municipal water conservation plan is on the order of $300 to $350 per dwelling unit. To achieve this on a voluntary basis, it would be advantageous to provide some incentive to the homeowner or renter. This could be done by providing a State income tax deduction patterned after the legislation which allows homeowners to deduct up to

55 percent (not to exceed $3,000) of the cost of installing solar heating devices.

Water pricing policy based on normal conditions must be adjusted during periods of restricted water use. Because water utilities operate with relatively high fixed costs that are not proportionately related to rate or amount of water use, substantial reductions in water use create comparable declines in revenue under conventional pricing policies based on unit charges. This situation is made more difficult for the water utility when consumers exceed utility expectations or goals for water-use reduction, as has occurred in the Bay Area in most service areas during the current drought.

Most of the agricultural water used in the Bay Area comes directly or indirectly from State and Federal water projects. The Carter Administration is currently in the process of reviewing the pricing structure of Federal water. One of the issues being investigated is how to promote water conservation through pricing. Raising the price of agricultural water or adding incentive for conservation could have a large impact on agricultural water use. Any such revision should be carefully reviewed to study the impact on agriculture in the Bay Area. Agricultural water conservation is essentially a statewide issue. Legislation is needed dealing with sharing the costs of agricultural water conservation. If State grants are made available to improve irrigation efficiency, they could be channeled through appropriate irrigation or water districts who could then take responsibility for maximizing the water saved in their district for the amount of money available.

Wastewater Reclamation

Reuse is generally a cost-effective source of water supply if State and Federal construction grants are available. Under the present grant-allocation policies, a State and Federal grant for a reuse project is only assured if the reclamation and reuse is the most cost-effective method of disposal. In assessing grant eligibility of projects which may not qualify under this criterion, it would be desirable to set a higher priority for those reuse projects which conserve fresh water. The short- and long-term need for water in an area should also be taken into account.

For those reuse projects which make available the replaced fresh water, financing of the local share of the costs should be done by the local water purveyor. It would generally be most equitable if costs of supplying the reuse market were averaged into the total water system cost, treating the reclaimed water as just another water supply.

Water Supply

Development of new sources of water supply should continue to be financed by the local water purveyor. There appears to be no reason to change the present practice of using general obligation and revenue bonds to finance capital costs and user charges and connection fees to finance ongoing operating charges.

The existing contracts between wholesale water supply agencies and water distribution agencies were concluded prior to the present concern for water conservation. Therefore, the pricing provisions do not generally reflect water shortage conditions or the need for conservation. Consideration should be given to eliminating minimum purchase requirements and substituting a flat rate plus a uniform unit charge up to the maximum entitlement.

CHAPTER VII

PRINCIPAL FINDINGS AND CONCLUSIONS

WATER SUPPLY

Existing Sources of Water Supply

Half of the water used in the Bay Area is imported. Major imported sources of water supply include the San Francisco Water Department's Hetch Hetchy system (which provides 17 percent of the total needs), various Delta diversions (13 percent), East Bay Municipal Utility District's Mokelumne system (12 percent), and the South Bay Aqueduct (8 percent). Groundwater is the principal source of local water, accounting for 27 percent of total needs of the Bay Area. Lake Berryessa provides 13 percent of the total needs and local reservoirs the remaining seven percent. In 1975 these sources provided a total of 1,592 mgd.

Water Supply Hierarchy

There are 80 water distribution agencies in the Bay Area that obtain their water in a variety of ways. In the Peninsula subregion (San Francisco and San Mateo counties) the San Francisco Water Department wholesales water to 22 water agencies that distribute the water to residential, commercial, and industrial customers. A few agencies use local sources. In the South Bay subregion (Santa Clara County) the Santa Clara Valley Water District and the San Francisco Water Department wholesale water to over 20 other water distribution agencies. In the East Bay subregion (Alameda and Contra Costa counties), the Contra Costa County Water District, the Alameda County Flood Control and Water Conservation District, Zone 7, and the San Francisco Water Department wholesale water to 12 water distribution agencies that, together with East Bay Municipal Utility District and the Alameda County Water District, meet the needs of customers in the East Bay. In the Marin-Sonoma subregion the Sonoma County Water Agency wholesales Russian River water to seven water distribution agencies. In the Napa-Solano subregion the Solano County Flood Control and Water Conservation District wholesales Lake Berryessa water to eight water distribution agencies and two irrigation

districts. Agricultural water in the Bay Area is mainly sold by irrigation or water districts in every subregion except Marin-Sonoma, where the farmers are entirely self-supplied.

Future Surface Water Supply

In the future, up to 2,512 mgd of water supply could be made available. Most of this increase in available water supply would result if six major new projects were constructed as planned. These sources and the maximum amount of water available are: expansion of the Hetch Hetchy Aqueduct, 100 mgd; American River Project, 134 mgd; San Felipe Division of the Central Valley Project, 134 mgd; Warm Springs Dam, 102 mgd; North Bay Aqueduct, 55 mgd; and West Sacramento Valley Canal, 120 mgd. All of these projects rely upon water sources outside the Bay Area except for Warm Springs Dam, which would be on a tributary of the Russian River.

WATER CONSERVATION

Residential Water Conservation Measures

The basic water conservation plan for the Bay Area should consist of a retrofit program for existing construction and a set of water-saving fixtures and devices for new construction. The retrofit program should consist of bottles to be installed in toilet tanks, shower flow-control inserts, and dye tablets for detecting leaks in toilets. It should be noted that the objectives of the retrofit program have already been achieved in much of the Bay Area due to the 1976-1977 drought and the efforts of water agencies and the public. Fixtures and devices installed in new construction should include low-flush toilets; shower flow controls; faucet flow controls; hot-water pipe insulation; thermostatic mixing valves on all lavatory, kitchen, shower, and bathtub faucets; pressure regulators; drip irrigation systems for discrete plants and trees; automatic timer-controlled sprinkler irrigation on turf and groundcover areas; proper ground preparation for turf; and use of drought-resistant landscaping.

Moderate Implementation of Residential Water Conservation

A moderate plan for residential water conservation associated with existing housing would involve supplying retrofit kits

free of charge at convenient central distribution centers. This is similar to what has been done during the 1976-1977 drought in many Bay Area communities. After the drought has ended, it is estimated that over the long-term this plan for existing residences will result in permanent water savings of 1.7 gallons per person per day (gpcd). For dwelling units that will be constructed, the moderate water conservation plan involves installation of low-flush toilets, shower flow controls, and faucet flow controls and would result in water savings of 16.6 gpcd.

Maximum Implementation of Residential Water Conservation

A reasonable maximum plan for residential water conservation associated with existing housing would use the same retrofit kit as the moderate plan, but would provide for the delivery of the kit free of charge door-to-door. Water savings achieved by this plan would be 4.1 gpcd. The reasonable maximum water conservation plan for new construction would require installation of low-flush toilets, shower flow controls, faucet flow controls, hot-water pipe insulation, thermostatic mixing valves, pressure regulators, drip irrigation systems, automatically timed sprinkler systems, proper ground preparation for landscaping, and drought-tolerant plantings. This plan would result in water savings of 18.6 gpcd in inside use and 13 percent in outside use.

Effects of Public Education and Local Water Shortages

Present drought-related public education programs should be continued on a long-term basis. It should be aimed at reducing unnecessary water use by changing personal habits, using more efficient devices and techniques, and modifying traditional western landscaping. It is estimated that if these programs were to continue, an additional water savings of five percent could be obtained in all water-use categories (residential, commercial, industrial, and public authority). Savings in the commercial sector are predicated upon continued application of the techniques used in the 1976-1977 drought, such as the use of toilet and faucet devices, recycling of water, and reduction of landscape irrigation water applications. Savings in the industrial sector are based upon applying the same methods as are used for the commercial sector plus in-plant recycling of water, which was begun in earnest recently due to the drought and higher charges for municipal wastewater treatment. An additional five percent savings is expected in all water-use categories if a local water shortage in the Bay Area were publicized by the news media.

Agricultural Water Conservation

Improvement of irrigation practices on farms would be effective in substantially reducing water use. Water savings of 30 percent could be achieved on farms where it is possible and practical to convert flood or furrow irrigation practices to more efficient methods such as well-engineered sprinkler and drip-irrigation systems. Other effective water conservation practices include automatic-timer soil-moisture systems, night irrigation, and alternate middle irrigation on fruit trees. At the irrigation district level additional water savings can be achieved by improving the distribution system and reducing losses. Some of these improvements called for in the plan were implemented during the 1976-1977 drought. It is estimated that an overall five percent savings could be achieved by selective application of these methods.

WATER USE PROJECTIONS

Projected Municipal Water Use

A 50 percent increase in municipal water use is projected in the Bay Area over the next 25 years. Municipal water use will increase most rapidly in Solano County (167 percent by year 2000). Increases in other counties will be: Alameda, 28 percent; Contra Costa, 60 percent; Marin, 81 percent; Napa, 49 percent; San Francisco, 2 percent; San Mateo, 21 percent; Santa Clara, 59 percent; and Sonoma, 117 percent.

Changing Pattern of Water Use

Water used by residential customers inside the home presently accounts for 37 percent of total municipal water use and is expected to increase 30 percent in the next 25 years. Water used outside the home by residential customers presently accounts for 17 percent of total municipal water use, but is expected to increase by 127 percent in the next 25 years. This shift in pattern of residential use will be due to the declining household size that is causing an increase in dwelling units that is approximately twice the rate of growth in population. Moreover, the majority of new housing stock is of the low-density type, which traditionally has had high outside water usage. Commercial and industrial water use is projected to increase 33 percent in

the next 25 years. Public authority water use is expected to increase by 57 percent by the year 2000.

Effect of Municipal Water Conservation

It is estimated that a reasonable voluntary water conservation plan for municipally-supplied water, as outlined in this study, would result in the following savings in total use by the year 2000: moderate plan, 8.8 percent or 124 mgd; and maximum plan, 11.4 percent or 160 mgd. In addition to these savings, a five percent savings in total demand (66 mgd in year 2000) would be realized during a localized water shortage in the Bay Area which received news media attention.

Projected Agricultural Water Use

Water used for agricultural irrigation is projected to decline in the Bay Area by about 15 percent during the next 25 years due to conversion of agricultural lands to urban uses. The expected changes in agricultural water use by county is: Alameda, -57 percent; Contra Costa, -22 percent; Marin, -62 percent; Napa, -8 percent; San Mateo, +18 percent; Santa Clara, -38 percent; Solano, -1 percent; and Sonoma, -31 percent.

Effects of Agricultural Water Conservation

Increasing on-farm efficiencies by selective conversion to more efficient methods or irrigation and continued farmer education will be effective in reducing agricultural water use. It is estimated that 15 percent of agricultural water requirements, amounting to about 100 mgd, could be saved in the year 2000.

WASTEWATER REUSE MARKETS

Potential Markets

Within the Bay Area there are approximately 40 existing and potential reclamation and reuse projects. In general, each of these involve advanced treatment at a sewage treatment plant for a portion of the wastewater and a distribution system to markets located usually less than 10 miles from the treatment plant. Presently 15 mgd of reuse is on-line or under construction in

the Bay Area. By 1980 the total reuse could be about 50 mgd and could increase by year 2000 to 152 mgd if all projects now in the preliminary planning stage are constructed. By the year 2000, 13 mgd could be on-line in the Peninsula subregion, 23 mgd in the South Bay subregion, 55 mgd in the East Bay subregion, 8 mgd in the Marin-Sonoma subregion, and 28 mgd in the Napa-Solano subregion. After 1990 approximately 20 percent of municipal wastewater could be reused if the market is fully developed. The projected reuse would be distributed approximately as follows: 43 percent to agricultural irrigation; 16 percent to landscape irrigation; 30 percent to industry; and 11 percent to other uses, such as groundwater recharge, marsh enhancement, and recreational lakes.

Water Savings Due to Reuse

Many of the wastewater reuse projects identified in this study would make available a like amount of fresh water for another use. Approximately 70 percent of the projected reuse market volume would be effective in reducing demands for fresh water. This water savings may be achieved by in-plant recycling of industrial effluent instead of using municipal effluent; however, the net effect of reducing water demands will be essentially the same. Within the Bay Area by the year 2000, as much as 12 mgd could be saved in the Peninsula subregion, 23 mgd in the South Bay subregion, 46 mgd in the East Bay subregion, 4 mgd in the Marin-Sonoma subregion, and 23 mgd in the Napa-Solano subregion. The total amount of water ultimately saved by reuse in the Bay Area, 108 mgd, would reduce needs for new water supply by 5.5 percent in the year 2000.

WATER RESOURCES ASSESSMENT

Water Use and Supply

Peninsula Subregion. In 1975 the Peninsula subregion had an adequate reserve supply (defined as the difference between total use and deliverable supply). By the year 2000, if no new water supply projects were built, the reserve would probably not be adequate protection against a drought of severity equal to the 1976-1977 drought. Water conservation and reuse would help restore the year 2000 reserve capacity to its 1975 level. Expansion of the Hetch Hetchy supply

system in conjunction with a moderate level of water conservation and complete implementation of identified reuse markets would assure the subregion of an adequate supply in case of a recurrence of conditions comparable to the 1976-1977 drought.

South Bay Subregion. Currently the South Bay subregion has a reserve capacity of water due primarily to extensive groundwater resources. In the future, as the subregion becomes more dependent upon imported surface water, a larger reserve will be needed. The proposed San Felipe project will provide an additional reserve capacity. However, if water available from this and other sources is curtailed, as occurred during the 1976-1977 drought, a moderate level of water conservation would be needed in addition to this project to meet water demands.

East Bay Subregion. Based upon published minimum surface water yields, the East Bay subregion had an adequate reserve capacity in 1975. However, the 1976-1977 drought made it obvious that the apparent reserve did not exist. Importing additional water into the region as planned would probably meet demands through the year 2000. A substantial amount of reuse, however, could be developed in this subregion. If reuse were combined with new source development and moderate conservation, the reserve capacity in the East Bay subregion could be restored to about the 1975 pre-drought levels.

Marin-Sonoma Subregion. This subregion faced a potential water shortage in 1975. The shortage was the first to be realized in the Bay Area due to the 1976-1977 drought. Without water conservation, reuse, or development of new supplies, the deficit will grow to eight times its 1975 level. Construction of the Warm Springs Dam project and allocation of supplies throughout the subregion would alleviate the potential shortage. Implementation of moderate water conservation in combination with this project would be necessary to provide an adequate reserve.

Napa-Solano Subregion. The Napa-Solano subregion faces an immediate potential water shortage. Development of the West Sacramento Valley Canal Unit and completion of the North Bay Aqueduct would alleviate this problem, if surface water yield estimates made before the 1976-1977 drought are still accurate. If, as will probably be the case, these yields are less than previous estimates, a moderate level of water conservation plus these two water supply projects will be needed to meet water demands.

Environmental and Social Impacts

Aside from the above-mentioned effects on water resources, the water conservation, reuse, and supply plan will have no major impact upon other environmental or social factors. Energy usage will be reduced by water conservation. Energy requirements for development of new sources of water supply and wastewater reclamation and reuse would increase. Costs of water conservation would ultimately increase new home prices and rental unit prices on the average of less than one percent. Costs would eventually be recovered due to reduced water and energy charges.

Cost-effectiveness of Water Conservation, Reuse, and Supply

The relative cost-effectiveness of the three elements of the plan were compared on a project-by-project basis for each subregion. Conservation and reuse were considered to be cost-effective if their unit cost was less than the unit cost of developing the planned future water supply for that subregion. From this analysis the following general conclusions can be drawn. Moderate municipal water conservation is the least expensive (on a unit-cost basis) method of generating new water supplies, i.e., reducing demands for new water supply. Agricultural water conservation is also generally less expensive than importing new water to the Bay Area. Approximately 20 percent of the reuse projects would be highly cost-effective if State and Federal construction grants were available. Maximum water conservation is generally substantially more expensive than developing planned future sources of water supply and in comparison with these latter costs, cannot be considered cost-effective at this time. Wastewater reuse projects can compete with new water supply source development only if subsidized by State and Federal grants. Without subsidy, reuse would, except in a few cases, be difficult to justify as an economical source of new water.

Institutional Arrangements

Existing water and wastewater agencies, in general, have sufficient authority to implement water conservation and wastewater reclamation and reuse programs and to develop new sources of water supply. Only under mandatory water rationing would legislative, and perhaps major institutional, changes be required. Implementation of these plans would be greatly facilitated by better regional coordination of water conservation and wastewater

reclamation and reuse programs, and the potential for water exchanges. To achieve this better coordination, the formation of a new committee or group in the Bay Region is needed. A Water Resource Management Coordinating Committee could be formed to deal with all water-related activities and problems of a regional nature. The committee could be formalized by a joint powers agreement or operate as an informal committee. Membership on the Water Resource Management Coordinating Committee would consist of the major water purveyors, wastewater dischargers, and approximately six smaller water and wastewater agencies. Staff support could be provided by ABAG or the member agencies.

Financial Considerations

Methods should be developed to share the costs of water conservation among all those who benefit. For example, a State income tax deduction for homeowners would provide an incentive for installation of water conservation devices. Agricultural water conservation is essentially a statewide issue. Legislation is needed to establish a reasonable plan and to deal with the cost-sharing.

New methods of pricing during periods of restricted water use need to be developed by those agencies that suffered a significant loss of revenue during the 1976-1977 drought.

Reuse would sometimes be a relatively inexpensive source of water supply if State and Federal construction grants continue to be made available. If grant funding priorities are set among reuse projects, those which make existing water supply available for other existing uses should receive a higher priority than those which do not, especially if the service area is potentially water deficient.

Development of new sources of water supply should continue to be financed by the local water purveyor.

The pricing provisions set forth in existing contracts between water wholesalers and water distribution agencies do not encourage water conservation. Consideration should be given to eliminating minimum purchase requirements and substituting a flat rate plus a uniform charge up to the maximum entitlement.

APPENDIX A

WASTEWATER REUSE MARKET SURVEY

TABLE A-1

PENINSULA SUBREGION WASTEWATER REUSE MARKET SURVEY
ALL AREAS COMBINED

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture					400	400
Landscape		885	906	2786	3786	3801
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined				418	554	554
Commercial						
Other			1	62	62	62
Total		885	907	3266	4802	4817

TABLE A-2

PENINSULA SUBREGION WASTEWATER REUSE MARKET SURVEY
SAN FRANCISCO AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture						
Landscape	1932	180	180	720*	720*	720*
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		180	180	720	720	720

Distance to Market: 1.0 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 4.0 mgd daily average
Ultimate Design Capacity: 4.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $1,327,000 (1977)
Estimated O & M Cost: $86,000 (1977)
Estimated Unit Cost: 26.7¢/kgal; $87/acre-ft

*Excludes golf courses that can be served from the North San Mateo County Sanitation District

Source: "Final Environmental Impact Report and Statement-San Francisco Wastewater Master Plan, Appendix A-Study of the Potential for Reclamation of Wastewater" by J. B. Gilbert & Associates, 1974

TABLE A-3

PENINSULA SUBREGION WASTEWATER REUSE MARKET SURVEY
NORTH COASTSIDE & PACIFICA AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture						
Landscape	1979	220	220	516	904	904
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined				3	3	3
Commercial				35	35	35
Other						
Total		220	220	554	942	942

Distance to Market: 5.0 miles
Treatment Required: Secondary
Initial Design Capacity: 4.0 mgd daily average
Ultimate Design Capacity: 5.2 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $3,600,000 (1977)
Estimated O & M Cost: $120,000 (1977)
Estimated Unit Cost: 51.6¢/kgal; $168/acre-ft

Source: "Wastewater Reclamation Study for the North San Mateo County Sanitation District" by Kirker Chapman Associates

"San Mateo County Water Quality Management Program" by Jenks and Adamson, 1973

TABLE A-4

PENINSULA SUBREGION WASTEWATER REUSE MARKET SURVEY
CENTRAL COASTSIDE AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture					400	400
Landscape	1979	60	60	85	85	100
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		60	60	85	485	500

Distance to Market: 2.5 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 0.3 mgd daily average
Ultimate Design Capacity: 2.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $1,361,000 (1977)
Estimated O & M Cost: $79,500 (1977)
Estimated Unit Cost: 46.5¢/kgal; $151.4/acre-ft

Source: "San Mateo Mid-Coastside Project Report" by TYA et al. 1975

"San Mateo County Water Quality Management Program" by Jenks and Adamson, 1973

TABLE A-5

PENINSULA SUBREGION WASTEWATER REUSE MARKET SURVEY
NORTH BAYSIDE AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture						
Landscape		55*	76	1000	1612	1612
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined				415	551	551
Commercial				26	26	26
Other						
Total		55	76	1441	2189	2189

Distance to Market: 3 miles for each of the 3 systems
Treatment Required: Secondary + Filtration
Initial Design Capacity: 3 mgd daily average for each of the 3 systems
Ultimate Design Capacity: 3 mgd daily average for each of the 3 systems
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $4,523,000 (1977)
Estimated O & M Cost: $220,500 (1977)
Estimated Unit Cost: 35.2¢/kgal; $114.6/acre-ft

*San Francisco County Jail

Source: "San Mateo Water Quality Management Program" by Jenks and Adamson, 1973

Letter from City of Burlingame to RWQCB - 11/16/76

TABLE A-6

PENINSULA SUBREGION WASTEWATER REUSE MARKET SURVEY
CENTRAL BAYSIDE AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture						
Landscape	1977	370	370	465	465	465
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial			1	1	1	1
Other						
Total		370	371	466	466	466

Distance to Market: 5.0 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 3 mgd daily average
Ultimate Design Capacity: 3 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $1,941,614 (1977)
Estimated O & M Cost: $75,500 (1977)
Estimated Unit Cost: 40.6¢/kgal; $132.5/acre-ft

Source: "San Mateo County Water Quality Management Program" by Jenks and Adamson, 1973

Letter from City of San Mateo to RWQCB - 11/10/76

TABLE A-7

SOUTH BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
ALL AREAS COMBINED

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge		730	730	730	1460	1460
Irrigation						
Agriculture		160	1315	1635	1985	2835
Landscape		110	110	815	2795	3315
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined					450	450
Commercial						
Other		410	410	410	410	410
Total		1410	2565	3590	7100	8470

TABLE A-8

SOUTH BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
PALO ALTO AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge	1977	730	730	730	1460	1460
Irrigation						
Agriculture						
Landscape	1977	110	110	815	815	815
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other	1977	410	410	410	410	410
Total		1250	1250	1955	2685	2685

Distance to Market: 2.0 miles
Treatment Required: Secondary + Coagulation, Filtration
Initial Design Capacity: 4 mgd daily average
Ultimate Design Capacity: 6 mgd daily average
Operation Period: 50% for 6 mon/yr; 50% for 12 mon/yr
Estimated Total Capital Cost: $11,000,000 (1977)
Estimated O & M Cost: $196,500 (1977)
Estimated Unit Cost: 66.7¢/kgal; $217.4/acre-ft

Source: "Wastewater Reclamation for Beneficial Reuse for City of Palo Alto" by Jenks and Adamson, 1972

1990 recharge value is assumed as twice the presently designed value

TABLE A-9

SOUTH BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
MILPITAS AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture			685	685	685	685
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total			685	685	685	685

Distance to Market: 2.0 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 4.0 mgd daily average
Ultimate Design Capacity: 4.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $1,530,000 (1977)
Estimated O & M Cost: $85,500 (1977)
Estimated Unit Cost: 29.3¢/kgal; $95.5/acre-ft

Source: "Potential Reclaimed Water Markets-Milpitas Area" by Santa Clara Valley Water District, 1975

TABLE A-10

SOUTH BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
REMAINDER[1] OF NORTH SANTA CLARA COUNTY AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge					24400[2]	24400[2]
Irrigation						
Agriculture						
Landscape					1980	2500
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total					1980	2500

Distance to Market: 35 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 11.0 mgd daily average
Ultimate Design Capacity: 14.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $11,498,000 (1977)
Estimated O & M Cost: $298,000 (1977)
Estimated Unit Cost: 45.1¢/kgal; $146.9/acre-ft

[1] Excludes cities of Palo Alto and Milpitas, includes area north of I-280

[2] Chances of this project being implemented appear small due to public health problems and thus quantities were not included in the total

Source: "Water Reclamation and Reuse - A Study for the Santa Clara County Flood Control and Water District - Phase I Final Report" by Consoer-Bechtel, 1973

TABLE A-11

SOUTH BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
GILROY-MORGAN HILL AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge					26200*	
Irrigation						
Agriculture	1977	160	630	950	1300	2150
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined					450	450
Commercial						
Other						
Total		160	630	950	1750	2600

Distance to Market: 2.0 miles
Treatment Required: Secondary
Initial Design Capacity: 1.0 mgd daily average
Ultimate Design Capacity: 12.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $2,052,000 (1977)
Estimated O & M Cost: $88,000 (1977)
Estimated Unit Cost: 6.5¢/kgal; $21.3/acre-ft

*This use not included in total because chances of implementation appear to be small due to public health problems.

Source: "Environmental Impact Report for the cities of Gilroy and Morgan Hill" by J. B. Gilbert & Associates, 1977

"Water Reclamation and Reuse - A Study for the Santa Clara County Flood Control and Water District - Phase I Final Report" by Consoer-Bechtel, 1973

TABLE A-12

EAST BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
ALL AREAS COMBINED

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture		1000	1000	1450	2360	2360
Landscape		130	130	1085	1085	1085
Open Space						
Marsh Enhancement				540	540	540
Recreational Lake						
Industrial						
Cooling			5480	9570	9570	9570
Process				5480	5480	5480
Other						
Combined				180	180	180
Commercial						
Other		365	730	730	730	730
Total		1495	7340	19035	19945	19945

TABLE A-13

EAST BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
NORTHERN BAYSHORE CITIES AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture						
Landscape				560[1]	560	560
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling				4090[2]	4090	4090
Process						
Other						
Combined						
Commercial						
Other			365	365	365	365
Total			365	5015	5015	5015

Distance to Market: 15 miles
Treatment Required: Secondary + Coagulation, Filtration, Nitrification
Initial Design Capacity: 14 mgd daily average
Ultimate Design Capacity: 14 mgd daily average
Operation Period: 12 mon/yr
Estimated Total Capital Cost: $27,700,000 (1977)
Estimated O & M Cost: $1,027,000 (1977)
Estimated Unit Cost: 87.4¢/kgal; $285/acre-ft
Above capacities and costs applicable to Notes 1 and 2, see below

[1]Similar to EBMUD Alt. 112A w/o Tilden Park, U.C. Berkeley, and Mt. View Group

[2]EBMUD Alt. 111

Source: "Alternative Reclaimed Water Systems - An Interim Report" by EBMUD, June 1976

TABLE A-14

EAST BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
SAN LEANDRO AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture						
Landscape				165[1]	165	165
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other	1978	365[2]	365	365	365	365
Total		365	365	530	530	530

Distance to Market: 1.5 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 1.0 mgd daily average
Ultimate Design Capacity: 1.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $1,130,000 (1977)
Estimated O & M Cost: $27,000 (1977)
Estimated Unit Cost: 65.6¢/kgal; $213.9/acre-ft
Above capacities and costs applicable to Note 1, see below

Source: [1]"Alternative Reclaimed Water Systems - An Interim Report" by EBMUD, June 1976

[2]"Environmental Impact Report for San Leandro Filter Plant Reclamation Facility" by EBMUD, 1976

TABLE A-15

EAST BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
UNION SANITARY DISTRICT AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture				1450	1450	1450
Landscape				360	360	360
Open Space						
Marsh Enhancement				540	540	540
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined				180	180	180
Commercial						
Other						
Total				2530	2530	2530

Distance to Market: 2.0 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 7 mgd daily average
Ultimate Design Capacity: 7 mgd daily average
Operation Period: 12 mon/yr
Estimated Total Capital Cost: \$12,700,000 (1977)
Estimated O & M Cost: \$52,000 (1977)
Estimated Unit Cost: 41.9¢/kgal; \$136.4/acre-ft

Source: "Wastewater Reclamation and Reuse Study for the Union Sanitary District Area - Appendix A to Draft EIS for East Bay Dischargers Water Quality Management Program Phase I" by U.S. EPA, 1976

Note: Reuse market in Fremont-Newark considered too far from Alvarado STP to be economically supplied with reclaimed water. Seven mgd could be supplied in Union City Area.

TABLE A-16

EAST BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
LIVERMORE-AMADOR VALLEY AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture		1000	1000	0	910	910
Landscape		130	130	0		
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		1130	1130	0	910	910

Distance to Market: 5.0 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 3 mgd daily average
Ultimate Design Capacity: 3 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $1,942,000 (1977)
Estimated O & M Cost: $75,500 (1977)
Estimated Unit Cost: 40.0¢/kgal; $130.4/acre-ft

Source: Personal communication with ABAG

TABLE A-17

EAST BAY SUBREGION WASTEWATER REUSE MARKET SURVEY
CENTRAL CONTRA COSTA AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture						
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling			5480	5480	5480	5480
Process				5480	5480	5480
Other						
Combined						
Commercial						
Other						
Total			5480	10960	10960	10960

Distance to Market: 5.0 miles
Treatment Required: Secondary + Filtration, Nitrification, Softening
Initial Design Capacity: 15.0 mgd daily average
Ultimate Design Capacity: 30.0 mgd daily average
Operation Period: 12 mon/yr
Estimated Total Capital Cost: $20,000,000 (1977)
Estimated O & M Cost: $1,205,000 (1977)
Estimated Unit Cost: 24.3¢/kgal; $79.1/acre-ft

Source: "Contra Costa County Water District User Cost Study" by James M. Montgomery Consulting Engineers, 1974

TABLE A-18

MARIN-SONOMA SUBREGION WASTEWATER REUSE MARKET SURVEY
ALL AREAS COMBINED

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture		1457	4925	6320	7895	9250
Landscape		15	240	300	590	800
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		1472	5165	6620	8485	10050

TABLE A-19

MARIN-SONOMA SUBREGION WASTEWATER REUSE MARKET SURVEY
SOUTH-CENTRAL MARIN AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture						
Landscape			75	125	180	200
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total			75	125	180	200

Distance to Market: 2.6 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 0.5 mgd daily average
Ultimate Design Capacity: 1.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $480,000 (1977)
Estimated O & M Cost: $31,500 (1977)
Estimated Unit Cost: 35.6¢/kgal; $116.0/acre-ft

Source: Personnal communication with Marin Municipal Water District, January 25, 1977

TABLE A-20

MARIN-SONOMA SUBREGION WASTEWATER REUSE MARKET SURVEY
NORTH MARIN AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture			755	865	975	1100
Landscape	1976	15	165	175	410	600
Open Space						
Marsh Enhancement			Possible at Las Gallinas			
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		15	920	1040	1385	1700

Distance to Market: System #1 = 1 mile; System #2 = 2 miles
Treatment Required: System #1 = Secondary + Filtration
System #2 = Secondary
Initial Design Capacity: System #1 = 3 mgd daily average
System #2 = 6 mgd daily average
Ultimate Design Capacity: System #1 = 3 mgd daily average
System #2 = 6 mgd daily average
Operation Period: 6 mon/yr for both systems
Estimated Total Capital Cost: $1,764,000 (1977)
Estimated O & M Cost: $165,800 (1977)
Estimated Unit Cost: 18.4¢/kgal; $59.9/acre-ft
System #1 = Las Gallinas; System #2 = Novato Subregional

Source: "Las Gallinas Valley Wastewater Reclamation Project - Draft Environmental Impact Report" by Madrone Associates, 1975

"Marin-Sonoma Wastewater Program Analysis" by J. Warren Nute et al, 1975

TABLE A-21

MARIN-SONOMA SUBREGION WASTEWATER REUSE MARKET SURVEY
WEST MARIN AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture	1976	17	50	55	60	70
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		17	50	55	60	70

Distance to Market: System #1 = 1.0 mile; System #2 = 1.0 mile
Treatment Required: Secondary for both systems
Initial Design Capacity: System #1 = 0.04 mgd daily average
System #2 = 0.05 mgd daily average
Ultimate Design Capacity: System #1 = 0.04 mgd daily average
System #2 = 0.05 mgd daily average
Operation Period: 12 mon/yr for both systems
Estimated Total Capital Cost: $790,000 (1977)
Estimated O & M Cost: $21,500 (1977)
Estimated Unit Cost: 240.0¢/kgal; $782.3/acre-ft
Above capacities and costs apply to Tomales Bay (System #1) and Pt. Reyes Station (System #2); Bodega Bay is on-line

Source: "Project Report and Feasibility Study for Bodega Bay Wastewater Treatment and Disposal System" by Kirker Chapman & Associates, 1972

"Facility Plan and EIR for Pt. Reyes Station" by North Marin Municipal Water District, 1976

"Facility Plan and EIR for Tomales Bay" by North Marin Municipal Water District, 1974

TABLE A-22

MARIN-SONOMA SUBREGION WASTEWATER REUSE MARKET SURVEY
SOUTHERN SONOMA AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture			1400	1800	2200	2700
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total			1400	1800	2200	2700

Distance to Market: 2.5 miles
Treatment Required: Secondary
Initial Design Capacity: 5.7 mgd daily average
Ultimate Design Capacity: 7.4 mgd daily average
Operation Period: 12 mon/yr
Estimated Total Capital Cost: $10,600,000 (1977)
Estimated O & M Cost: $600,000 (1977)
Estimated Unit Cost: 65.8¢/kgal; $214.5/acre-ft

Source: "Environmental Impact Report for Marin-Sonoma Wastewater Management Program" being prepared by J. B. Gilbert & Associates

TABLE A-23

MARIN-SONOMA SUBREGION WASTEWATER REUSE MARKET SURVEY
SONOMA VALLEY AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture			720	800	1060	1380
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total			720	800	1060	1380

Distance to Market: 6.0 miles
Treatment Required: Secondary
Initial Design Capacity: 3.0 mgd daily average
Ultimate Design Capacity: 3.8 mgd daily average
Operation Period: 12 mon/yr
Estimated Total Capital Cost: $2,000,000 (1977)
Estimated O & M Cost: $60,000 (1977)
Estimated Unit Cost: 18.2¢/kgal; $59.4/acre-ft

Source: "Project Report for Water Reclamation and Pollution Control Facilities - Sonoma Valley County Sanitation District" by Trotter-Yoder & Associates, 1975

TABLE A-24

MARIN-SONOMA SUBREGION WASTEWATER REUSE MARKET SURVEY
SANTA ROSA AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture	1977	1440	2000	2800	3600	4000
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		1440	2000	2800	3600	4000

Distance to Market:
Treatment Required: Secondary
Initial Design Capacity: 20.0 mgd daily average
Ultimate Design Capacity: 20.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: project built
Estimated O & M Cost:
Estimated Unit Cost

Source: Personnal communication with City of Santa Rosa, July 18, 1977

TABLE A-25

NAPA-SOLANO SUBREGION WASTEWATER REUSE MARKET SURVEY
ALL AREAS COMBINED

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture		110	5260	6110	7010	9230
Landscape			45	45	50	50
Open Space						
Marsh Enhancement			1400	2100	3000	3000
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		110	6705	8255	10060	12280

TABLE A-26

NAPA-SOLANO SUBREGION WASTEWATER REUSE MARKET SURVEY
NAPA-CARNEROS AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture			1000	1000	1200	1500
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total			1000	1000	1200	1500

Distance to Market: 4.0 miles
Treatment Required: Secondary
Initial Design Capacity: 6.0 mgd daily average
Ultimate Design Capacity: 8.0 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $1,850,000 (1977)
Estimated O & M Cost: $37,000 (1977)
Estimated Unit Cost: 15.5¢/kgal; $50.5/acre-ft

Source: "Carneros Area Agricultural Water Supply Study" by Napa County Flood Control and Water Conservation District, October 1976

TABLE A-27

NAPA-SOLANO SUBREGION WASTEWATER REUSE MARKET SURVEY
YOUNTVILLE AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture	1939	60	60	80	80	80
Landscape			45	45	50	50
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		60	105	125	130	130

Distance to Market: 1.0 mile
Treatment Required: Secondary
Initial Design Capacity: 0.3 mgd daily average
Ultimate Design Capacity: 0.3 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $309,000 (1977)
Estimated O & M Cost: $12,000 (1977)
Estimated Unit Cost: 63.0¢/kgal; $205.4/acre-ft

Source: "Project Report on Wastewater Treatment and Disposal - City of Yountville - February 1975 Amendment" by Kennedy Engineers, 1975

TABLE A-28

NAPA-SOLANO SUBREGION WASTEWATER REUSE MARKET SURVEY
CALISTOGA AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture			50	80	80	100
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total			50	80	80	100

Distance to Market: 1.7 miles
Treatment Required: Secondary
Initial Design Capacity: 0.4 mgd daily average
Ultimate Design Capacity: 0.4 mgd daily average
Operation Period: 6 mon/yr
Estimated Total Capital Cost: $200,000 (1977)
Estimated O & M Cost: $12,000 (1977)
Estimated Unit Cost: 36.8¢/kgal; $120/acre-ft

Source: "Amendment to the Project Report on Wastewater Treatment Improvements - Wastewater Reclamation Pipeline, City of Calistoga, California" by Kennedy Engineers, December 1976

TABLE A-29

NAPA-SOLANO SUBREGION WASTEWATER REUSE MARKET SURVEY
ST. HELENA AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture		50	50	50	50	50
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total		50	50	50	50	50

Distance to Market: Existing Project
Treatment Required:
Initial Design Capacity:
Ultimate Design Capacity:
Operation Period:
Estimated Total Capital Cost:
Estimated O & M Cost:
Estimated Unit Cost:

Source: "Reclamation and Reuse of Wastewater in San Francisco Bay Region" by BASSA, 1975

TABLE A-30

NAPA-SOLANO SUBREGION WASTEWATER REUSE MARKET SURVEY
FAIRFIELD-SUISUN AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture			1900*	2500	3000	4300
Landscape						
Open Space						
Marsh Enhancement			1400*	2100	3000	3000
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total			3300	4600	6000	7300

Distance to Market: 2.5 miles
Treatment Required: Secondary + Filtration
Initial Design Capacity: 12 mgd daily average
Ultimate Design Capacity: 20 mgd daily average
Operation Period: 12 mon/yr
Estimated Total Capital Cost: $5,240,000 (1977)
Estimated O & M Cost: $497,000 (1977)
Estimated Unit Cost: 12.2¢/kgal; $39.8/acre-ft

*Distribution of effluent assumes that Solano Irrigation District uses all effluent during growing season

Source: "Draft Environmental Impact Report - Wastewater Management and Reclamation Facilities - City of Fairfield" by J. B. Gilbert & Associates, 1974

TABLE A-31

NAPA-SOLANO SUBREGION WASTEWATER REUSE MARKET SURVEY
VACAVILLE AREA

Identified Markets	Project		Projected Reuse, 10^6gal			
	Date on Line	Quantity 10^6gal	1980	1985	1990	2000
Groundwater Recharge						
Irrigation						
Agriculture			2200	2400	2600	3200
Landscape						
Open Space						
Marsh Enhancement						
Recreational Lake						
Industrial						
Cooling						
Process						
Other						
Combined						
Commercial						
Other						
Total			2200	2400	2600	3200

Distance to Market: 5.0 miles
Treatment Required: Secondary + Coagulation + Filtration
Initial Design Capacity: 6.5 mgd daily average
Ultimate Design Capacity: 8.0 mgd daily average
Operation Period: 12 mon/yr
Estimated Total Capital Cost: $7,600,000 (1977)
Estimated O & M Cost: $258,500 (1977)
Estimated Unit Cost: 35.4¢/kgal; $115.5/acre-ft

Source: "Draft Environmental Impact Report for Upgrading and Expanding the Easterly Sewage Treatment Facilities, Vacaville, California" by VTN Consolidated, Inc., February 1975

APPENDIX B

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